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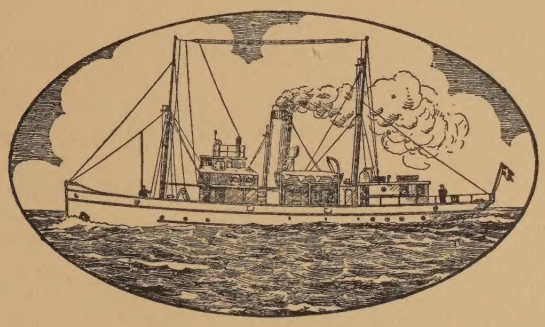
Report

of

The Danish Biological Station

to

The Ministry of Agriculture and Fisheries



XLVIII.

1943-45.

By

H. Blegvad, Ph. D.
Director

Copenhagen. C. A. Reitzel.
1946.

The Reports from the Danish Biological Station (Nos. I—XXI) are published in the official Danish "Fiskeri-Beretning" for the years 1890—91 until 1912. After this year they appear as special publications. The Reports I—XXXII are edited by Dr. C. G. Joh. Petersen, the Reports XXXIII—XXXVI by Dr. A. C. Johansen and the later Reports by Dr. H. Blegvad.

I. *C. G. Joh. Petersen:* Fiskenes biologiske Forhold i Holbæk Fjord. (1890—91)*) 63 pp. 1 Chart. Out of print.

II. *Idem:* On the Eggs and Breeding of our Gobiidæ. (1891—92.) 9 pp. Two Plates. Out of print.

III. *Idem:* The Pelagic Life in Fænø Sound etc. (1892—93.) 38 pp. Tables. Out of print.

IV. *Idem:* On the Biology of our Flat-fishes and on the decrease of our Flat-fish Fisheries. (1893—94.) 146 pp. 2 Plates. 1 Chart. Many Tables. Out of print.

V. *Idem:* The common Eel (*Anguilla vulgaris* T.) gets a Particular Breeding-dress before its Emigration to the Sea. (1894—95.) 35 pp. With 2 Plates.
Etc. 64 pp. Out of print.

VI. *Idem:* The Yearly Immigration of young Plaice into the Limfjord etc. (1895—96). 48 pp. 1 Chart. 2 Tables. Out of print.

VII. *Idem:* Plankton-Studies in the Limfjord. 1897. 23 pp. 1 Map. 4 Tables. Out of print.

VIII. *Idem:* An Otter-Seine for the Exploration of Deeper-Seas. 1898. 24 pp. With 10 Figures. Out of print.

IX. *Idem:* Trawlings in the Skager Rack and the Northern Cattegat in 1897 and 98. 1899. 56 pp. With one Map. Out of print.

X. *Idem:* List of the "Aalerusestader" in Denmark etc. — Smaller Communications. 1899 and 1900. 37 pp.

XI. *Idem:* I. The Biology of the Cod in the Danish Seas. II. On other Codfishes in our Seas. III. Some General Observations on Protection, Legislation etc. IV. Alterations and Improvements on Otter-seines for Zoological Purposes. 1900 and 1901. 44 pp.

XII. *Idem:* I. Where, and under what Conditions, can the Eggs of Plaice be developed into Young Fish within the Skaw? II. On the Young Stages of the genus *Zeugopterus.* (With one Plate). III. Can we enter into Competition with the Foreign Steam-trawlers in our Seas outside the Danish Territorial Limit. 1902 and 1903. 33 pp.

XIII. *A. Otterstrøm:* Eggs and Young of Fishes in the Danish Waters. (Investigations during 1904 and earlier years.) 1903 and 1904. 85 pp.

XIV. I. *C. G. Joh. Petersen:* The Influence of Light on the Migrations of the Eel. II. *K. I. Gemzøe:* Age and Rate of Growth of the Eel. 1906. 39 pp.

XV. *Idem:* I. First Report on the Oysters and Oyster Fisheries in the Lim Fjord. (70 pp.) 1908.

XVI. *C. H. Ostenfeld:* On the Ecology and Distribution of the Grass Wrack (*Zostera marina*) in Danish Waters. With 9 figures. 1908. 62 pp.

XVII. *C. G. Joh. Petersen:* II. Second Report on the Oyster and Oyster Fisheries in the Lim Fjord. 1908. (24 pp).

XVIII. *C. G. Joh. Petersen:* I. The Yield of the Limfjord fisheries in recent years and the transplantation of Plaice in 1908. With 6 tables and 1 Chart. II. Biological investigations on the stock of Plaice in the Limfjord. With 3 Tables. III. The Yield of the Prawn fishery from 1885—1907 and its improvement by means of protection. With 3 Tables. 25 pp. 1909.

XIX. *Idem:* Some Experiments on the Possibility of combating the harmful Animals of the Fisheries, especially the Whelks in the Limfjord. 20 pp. 1911.

XX. *C. G. Joh. Petersen* og *P. Boysen Jensen:* Valuation of the Sea. I. Animal Life of the Sea-Bottom, its food and quantity. With 6 Tables, 3 Charts and 6 Plates. 81 pp. 1911.

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*) The figures in ( ) refer to the "Fiskeri-Beretning" for the years quoted.

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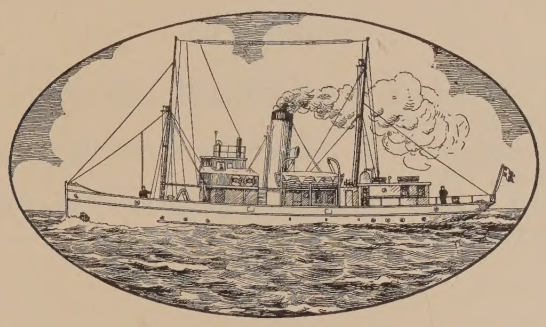

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On the Waste Fish Fishery

By

H. BLEGVAD

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The fishing for "waste fish", i. e. fishes that are unfit for human food but are used for fish fodder or fish meal, is of old date in this country, but during recent years it has risen so enormously, that many objections have been raised against it. It has been maintained that in landing the heavy catches of young fish we decrease the stocks of grown-up fishes to a very great extent and especially that the waste fish fishery is the cause of the failure of the herring fishery in our inner waters during recent years. For the purpose of examining this problem the Biological Station from time to time took out samples of waste fish and examined them in order to ascertain what species of fish are taken in the waste fish fishery and to throw a light upon the character of the whole of this fishery.

The yield of the fishery.

As mentioned waste fish are used partly as fish fodder in the trout pond-farms, partly as raw material in the fish meal factories. Under normal conditions offals from slaughter-houses (beside fish) were used as fish fodder. But as a consequence of the war situation the demand for fish to be used as fodder in the ponds rose rapidly on account of the scantiness of slaughter-house offals. At the same time the lack of oil and fish meal in connexion with the rising prices caused that the fish meal factories during the period of war could buy up ever increasing amounts of waste fish at prices that were remunerative to the fishermen.

As a matter of fact we find a rapid rise in the yield of the waste fish fishery, especially during the war, which appears distinctly from the statistics. In former times the great majority of waste fishes were landed as by-products of other fisheries, for instance the pound net fishery, the herring and sprat trawl fisheries and the deep-sea prawn fishery, but now there arose, particularly in the Skagerak and the Kattegat, a special fishery for waste fish all the year round with Danish seines and board seines and in summer with shore seines. The main centre of this fishery is Skagen. The mesh-width of the Danish seines and board seines used here range between 40 mm. at the mouth and 11 mm. at the codend. The bag consists of meshes of 40, 30, 20 and 11 mm.; the 11 mm. width is found at the codend, which is about 4 m. long. In the shore seine the bag is of the same mesh width except the codend, the meshes of which are only 8 mm. At Løkken (W. Coast of Jutland) they use another gear which is like the shore seine with the only exception that the wings are deeper, so that the gear when used in shallow water works like a net allowing no young fish to escape.

A look at the fishery statistics contained in the annual fishery reports will show that it is difficult to get exact figures for the catches of waste fish in earlier years when the fishery was of no great importance. 1939 is the first year in which the catches of waste fish are put down separately, but we get an idea of the time at which this fishery begins to develop if we examine the figures of the fishery reports for the yields of the whiting fishery because this fish constitutes the main part of the waste fish

in the Skagerak and the Kattegat, the principal centres of this fishery.

The fishery report gives the following figures for the catches of whiting (in tons) in the different waters:

Year	The North Sea	The Skage-rak	The Katte-gat	The Belt Sea	Total	Price in Øre per kg.
1925	178	—	5	0.6	186	28
1926	56	3	7	3	78	20
1927	102	6	5	7	120	15
1928	154	144	3	6	310	21
1929	164	173	197	11	545	10
1930	79	423	32	46	580	9
1931	54	789	55	19	968	5
1932	129	987	18	100	1243	4
1933	31	1531	7	121	1691	4
1934	3	2152	1	68	2225	3
1935	10	2698	37	37	2782	3
1936	31	3398	258	90	3778	4
1937	52	3677	245	46	4021	4
1938	3	3719	567	57	4347	3
1939	3	6860	606	27	7479	5
1940	30	2118	92	40	2283	29

The fishery in the Sound and the Baltic is quite insignificant and is not included here. In other words the price of whiting was comparatively high during the period between 1925 and 1928 but suddenly fell to 10 Øre per kg. in 1929 and even to 3—5 Øre per kg. in the years 1930—39. This undoubtedly means that the whiting caught in the years 1925—28 were used for human food whereas the catch figures of the later years include large amounts of waste fish. At the same time there is a rising importance of the whiting fishery in the Skagerak and the Kattegat while it decreases in the North Sea, all these facts bearing witness to the rapid development of the waste fish fishery. As to the catch yields of 1938 and 1939 it is stated in the fishery reports that 98 and 99 per cent., respectively, were landed at Skagen and that "the whiting is used exclusively for fish fodder and fish meal". The figures for 1940 include only consumption fish, which also appears from the comparatively high price mentioned above. It is stated in the fishery report that besides this at least 7.5 mill. kg. of waste fish were taken in 1940, the majority consisting of small whiting. 6.8 mill. kg. of them were sold from Skagen; the price was about 7—10 Øre per kg.

It appears from the data given above that the waste fish fishery began to increase in the Skagerak and the Kattegat about 1929. During the years between 1933 and the beginning of the war there was a further considerable increase of this fishery. But even this increase was totally outstripped by the enormous development during the war when, according to the fishery reports, the following quantities of waste fish were landed:

In 1939:	11	mill. kg. at a value of	0,6	mill. Kr.
In 1940:	7,5	—	0,5	—
In 1941:	11	—	1,4	—
In 1942:	18,6	—	3,7	—
In 1943:	23,7	—	2,8	—

In other words the quantity was more than doubled in the course of 4 years.

This again means that while the catches of waste fish in earlier days were only a by-product of other fisheries and were of so small importance, that they were not put down separately in the fishery statistics, they have risen during the war to nearly the same weight yield as those of our two principal fishes in normal years, the cod and the plaice (20—25 mill. kg. of each) although the value of the waste fish landed is but a fraction of that of the two other species of fish.

The following table, which has been made by Mr. A. Strubberg, Head Clerk of the Fisheries Directorate, gives an idea of the waters in which this fishery is especially carried on and of the quantities landed at the different places.

By fishmongers living within the following districts of the Fishery Control these amounts of waste fish were purchased in 1943:

District	Metric tons
Esbjerg	261
Ringkøbing	11
Ulfborg	2
Struer	169
Thyborøn	226
Nykøbing Mors	614
Thisted	1 058[1])
Hirtshals	4 174
Skagen	7 310
Frederikshavn	5 166
Aalborg	278
Hadsund	449
Randers	856
Grenaa	366
Aarhus	703
Fredericia, Jutland side	301
Fredericia, Funen side	190
Aabenraa	160
Total...	22294

[1]) From shore seines at the Skagerak coast.

Carried over...	22294	Tons
Svendborg	32	
Eastern side of Funen	794	
Masnedsund	76	
Karrebæksminde	169	
Lynæs	116	
Copenhagen	205	
Total...	23 686	Tons

In most cases the catches may be supposed to have been taken near the place where they are landed and sold, and so it will be seen that a very small quantity only comes from the North Sea; the great majority, that is to say three quarters of the total catches, originate from the Skagerak (from where the catches are taken to Hirtshals, Thisted and Skagen) and the northern Kattegat (catches taken to Skagen and Frederikshavn). No waste fish at all are landed at Bornholm.

The prices vary somewhat for the different areas as will appear from the following survey.

The greater part of the catches of waste fish in 1943 were sold at the following prices:

	kg.	Kr.	Mean price per kg.
The North Sea	254 650	17 900	7 Øre
The Skagerak	4 886 955	458 191	9 —
The Kattegat	14 190 418	1 737 636	12 —
The Sound	—	—	—
The Belt Sea	551 610	57 328	10 —
West. Baltic	15 000	2 100	14 —
East. —	895 062	114 754	13 —

For all auction sales were landed about 8,618,200 kg., the value of which was 1,067,000 Kr., a mean value of 12 Øre per kg.

In other words the price was lowest in the North Sea and the Skagerak where the whiting constitute the greater part of the waste fish and highest in the Limfjord and the western Baltic, in both of which localities most of the waste fish consists of small herring.

For the rest there have been very great variations in the prices of waste fish during these twenty years. If we make a survey of the yield of the "silding" fishery in the Limfjord ("silding" are small herring used exclusively for fish meal and fish fodder) and calculate the average prices, we get the following figures:

"Silding" from the Limfjord:

Year	kg.	Mean price per kg.
1925	800 000	abt. 4 Øre
1926	399 000	- 5 —
1927	390 000	- 3 —
1928	926 000	?
1929	400 000	?
1930	1 051 000	?
1931	860 000	?
1932	740 000	- 1,6 —
1933	701 000	- 1,5 —
1934	172 000	- 1,7 —
1935	160 000	- 0,9 —
1936	279 900	- 5,5 —
1937	242 000	- 2 —
1938	620 000	- 2,3 —
1939	191 000	- 2,6 —
1940	19 625	- 6,6 —
1941	291 000	- 12,7 —
1942	840 000	- 17,9 —
1943	895 000	- 13 —

It will be seen that before the war the price varied between less than 1 Øre and 5 Øre per kg. and that it rose very rapidly during the war (1940—43). In 1942 the maximum price was fixed legally at 14 Øre per kg. with an addition of 3 Øre per kg. for waste fish determined for fish fodder.

The composition of the catches.

It has already been mentioned that whiting, particularly in the northern waters, and small herring, particularly in the southern waters, constitute the main part of the waste fish. In former times many small dab were taken and used for fish fodder, especially in the waters round Funen and Samsø, but this fishery had to stop when a minimum size-limit for dab was introduced in 1934.

In Tables 1—8 we find the data of the samples of waste fish examined by the Biological Station.

Tables 1—4 include catches from the southern area, that is to say the central and southern Kattegat from Hals (at the mouth of the Limfjord towards the Kattegat) and southwards, the Belts and the western Baltic. Tables 5—8 deal with the northern area, i. e. the northern Kattegat and the Skagerak.

From Table 1 we see how many different kinds of animals were found in the samples examined from the southern area; against each species is stated its weight percentage of the whole sample. At the

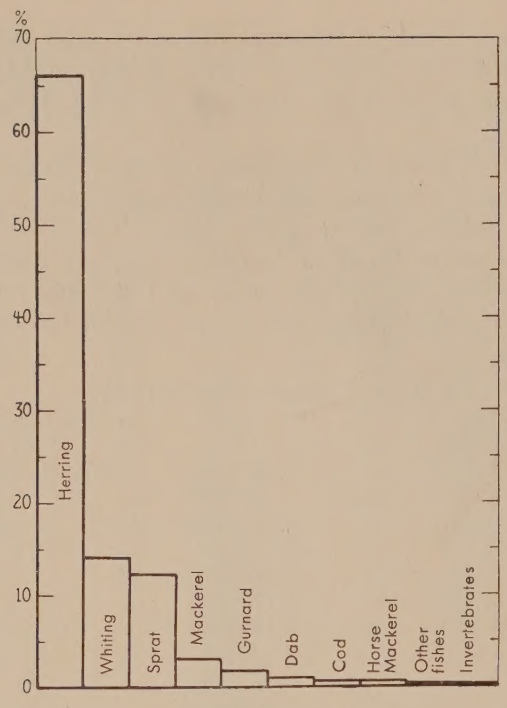

Figure 1.

bottom we find the total weights of the individual samples and in the right-hand column for each species its average percentage of the total material. These last figures are further illustrated by the graphical representation of Figure 1.

It is seen at once that nearly all catches consisted mainly of herring; in two samples only whiting predominated and in one sample mackerel. If we take all the samples examined in one, the weight of the small herring amounts to 66 per cent. of the whole catch; number 2 is the whiting with 14.2 per cent., closely followed by the sprat with 12.3 per cent. In other words these three kinds of fish constitute by far the greater part (92.5 per cent.) of the catches, and much smaller quantities are found of fishes like small mackerel, small cod, horse mackerel, common dab, long rough dab and gurnard. Invertebrates like starfish, crabs and others taken together make up only 0.2 per cent. of the whole catch material.

Tables 2, 3 and 4 show the size and weight of whiting, herring and sprat, respectively, in the catches of waste fish from the southern area. It will be noted that the mean size of the whiting captured is 16.62 cm. and the mean weight 49.2 g.; for herring the figures are only 12.9 cm. and 16.5 g. and for sprat even as low as 10.7 cm. and 12.2 g. It appears from the measuring tables that within all three species it is mainly youngs in their first year of life that are taken in the catches of waste fish.

In the same way as Table 1 Table 5 gives the composition of the catches in the northern area. Here the whiting predominates, constituting in weight an average of 52.9 per cent. of all catches as a whole. No. 2 is the herring with 18.8 and No. 3 the sprat with 10.4 per cent. of the total weight. Here, too, these three species of fish are the most important objects of the waste fish fishery, constituting together 82.1 per cent. of the total catches. Next to them come mackerel, Norway pout, cod and long rough dab; all other species of fish make up less than 1 per cent. of the weight amount, and of bottom animals there are only 0.2 per cent. (see Figure 2).

From Table 6 it is seen that the size of the whiting is somewhat varying, the mean length ranging between about 12 and about 23 cm. in the different catches, but altogether the mean length of the whole material, 16.63 cm., is only slightly greater than in the whiting from the southern area. However, the mean weight is considerably lower in the northern than in the southern area, viz. 43.9 against 49.2 g. This seems to show that the state of nutrition is better in the whiting of the southern area, a fact that is known from other species of codfish, for

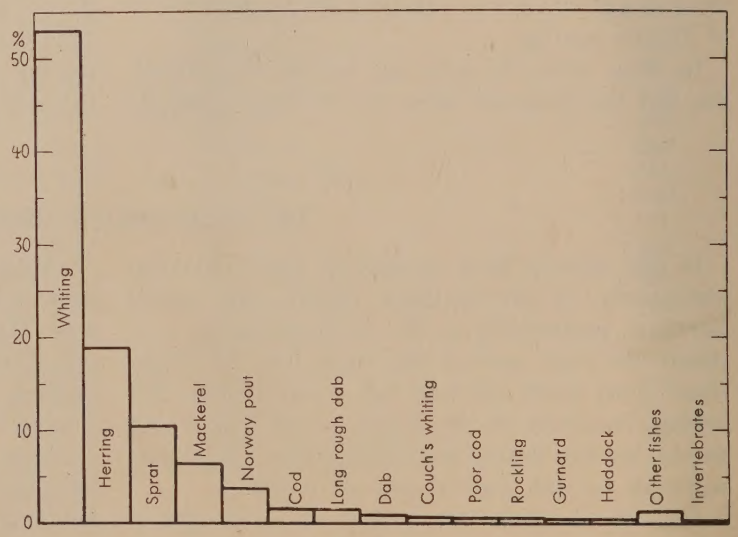

Figure 2.

instance haddock (E. M. Poulsen in Report 34 from the Biological Station, 1928).

Table 7 gives the sizes of the herring in the catches from the northern area. Here we find the same state of things as in the whiting: the mean length is a bit greater, but the weight considerably lower than in the southern area. Accordingly, it must be supposed that also the herring find better conditions of nutrition in the south than in the north.

Also the sprat are somewhat longer in the catches of the northern area though the mean weight is lower. This appears from Table 8 as compared with Table 4.

To complete the statements it may be added that some quantities of animals like starfish and stickleback in recent years sometimes occurred in the catches of waste fish from the southern waters. Such catches are not represented in the tables, but they are no doubt of very little importance as compared to the total amount. It is my conviction that the samples given here on the whole are typical of the composition of the catches of waste fish.

The influence of the waste fish fishery on the stock of fishes.

If we want to judge the influence of this fishery on the stock of fishes, it is necessary to look at each of the economically important species of fishes separately. We saw above that in the catches of waste fish there were only inconsiderable quantities of flat-fish and cod and that the bulk of the catches consisted of whiting, herring and sprat.

As far as the whiting is concerned it may be said that this species of fish never played any prominent part in the Danish fishery. It appears from the table on p. 6 that this species of fish did not grow really important in an economic respect until it appeared in the catches of waste fish. Moreover the stock of whiting as a whole, even with the present intense fishing for the small whiting, will hardly run the risk of being exhausted because the whiting is a migratory fish, which spawns in the open waters far from our coasts. In our inner waters full-grown whiting are extremely rare; here we only find the youngest year-classes.

As regards the herring conditions are somewhat different. It is well-known that in our waters we have different races[1]) of herring, some of which make long migrations while others are more local ones. It is evident that an intense fishing for small herring belonging to a race with remote spawning places — for instance the bank herring, which spawns along the eastern coasts of Scotland and England — will not influence the Danish fishery to the same extent as the fishing for local races that spawn in our inner waters and form the basis of a local fishery. It will therefore be necessary to look more closely at the races that are found among the small herring taken in the catches of waste fish.

From investigations made by Dr. Aage J. C. Jensen the following items of information may be given:

Northern area (the Skagerak and the northern Kattegat).

At Herthas Flak, 29-XI-1939:		
Autumn herring from the North Sea, mostly of the 1938 year-class	100	per cent.
N. of Skagen, 23-IV-1940:		
Autumn herring from the North Sea, 1938 year-class	25	
Autumn herring from the northern Kattegat, 1937 year-class	65	—
Autumn herring from the northern Kattegat, 1938 year-class	10	—
N. of Grenen, 15-X-1940:		
Autumn herring from the North Sea(?), 1939 year-class	66	—
Spring herring of Atlantic type, 1939 year-class, perhaps spawning in the northern Kattegat ("winter herring of the Kattegat")	34	—
N. of Hirtshals, 14-I-1941:		
Spring herring of Atlantic type, 1940 year-class, perhaps "winter herring of the Kattegat"	78	—
Autumn herring from the North Sea (bank herring?), year-class 1938 and a few ind. from 1937 and 1936	22	—

[1]) In this case a "race" is a stock of fish, which by different morphological characters (number of vertebrae, number of fin-rays, scales, etc.), determined by the mean figures, is clearly distinguished from other stocks of fish of the same species.

N. of Hirtshals, 1-II-1941:

Autumn herring from the North Sea, 1939 year-class	67	per cent.
Spring herring of Atlantic type ("winter herring of the Kattegat"?), 1939 year-class	17	—
Spring herring from Jammerbugt, 1938 year-class	16	—

N. of Hirtshals, 5-II-1941:

Spring herring of Atlantic type ("winter herring of the Kattegat"), 1940 year-class	60	—
Autumn herring from the North Sea(?), 1938 year-class	30	—
Coastal spring herring from the Kattegat or the Belt Sea	10	—

N. of Hirtshals, 15-II-1941:

Spring herring of Atlantic type ("winter herring of the Kattegat"?), 1940 year-class	84	—
Autumn herring from the North Sea	16	—

Sæby, 17-XII-1941:

Autumn herring from the North Sea, 1940 year-class	80	
Autumn herring from the North Sea (bank herring)	20	—

Frederikshavn, 14-I-1944:

Autumn herring from the North Sea, 1942 year-class	100	

WNW. of Hirtshals, 15-II-1944:

Autumn herring from the North Sea(?), 1942 year-class	100	—

WNW. of Hirtshals, 26-II-1944:

Coastal spring herring, presumably from the Skagerak or the Kattegat, 1943 year-class	92	
Herring with similar racial characters	8	—

Skagen, 26-II-1944:

Autumn herring from the North Sea (Shetland herring), 1942 year-class	100	—

Southern area (the Kattegat S. of Hals, the Belt Sea and the western Baltic).

Aarhusbugten, 13-XII-1939:

Autumn herring from the Skagerak or the North Sea, 1938(?) year-class	45	per cent.
Autumn herring from the Belt Sea, 1937 year-class	55	—

Aarhusbugten, 23-XII-1939:

Autumn herring from the North Sea, 1938 year-class	50	—
Coastal spring herring from the Belt Sea, 1938 year-class	50	—

Aarhusbugten, 16-XII-1940:

Autumn herring from the Skagerak or "winter herring of the Kattegat"(?), 1939 or 1940 year-class	80	—
Autumn herring from the Kattegat, 1938 year-class	15	per cent.
?	5	—

Vejle Fjord, 15-I-1941:

Mixture of several races, at any rate not Belt Sea herring (1939—40 year-class)	60	—
Autumn herring from the Kattegat	35	—
?	5	—

Holbæk, 29-IV-1942:

No doubt coastal spring herring from the northern Kattegat (not Belt Sea herring), 1941 year-class	100	—

Æbelø-Fynshoved, 8-VII-1942:

Autumn herring from the Kattegat	85	—
? (mixture?)	15	—

Aarhusbugten, 13-IX-1942:

Coastal spring herring from the northern Kattegat, 1942 year-class	70	—
Mixture of several races (not Belt Sea herring), 1942—43 year-class	30	—

Aarhusbugten, 18-X-1943:

North Sea autumn herring, 1942 year-class	87	—
Autumn herring from the northern Kattegat, 1941 year-class	13	—

At Trelle Skov, Fredericia, 29-IV-1944:

Coastal spring herring from the Kattegat or the Belt Sea, 1942 year-class	10	—
? (not Belt Sea herring)	90	—

Between Romsø and Sprogø, 11-V-1944:

Coastal spring herring from the northern Kattegat, 1943 year-class	100	—

Sønderborg, 21-XII-1944:

Spring herring from the Belt Sea or the western Baltic	100	—

It will be noted that the major part of the young herring taken in the northern area originates from the North Sea. A smaller portion originates from the northern Kattegat, and only in one case herring were found that had possibly come from the Belt Sea. The herring races of the North Sea and the northern Kattegat are distributed over vast areas, and some of them will migrate extensively, and so we may draw the conclusion beforehand that the waste fish fishery will hardly cause any serious damage to the herring fishery of these waters.

The following calculation has been made in order to examine how large amounts of herring have been removed by the waste fish fishery.

The following quantities of waste fish were bought in 1943 by the fish-mongers of these districts:

District	kg.
Esbjerg	261 000
Ringkøbing	11 000
Thyborøn	226 000
Hirtshals	4 174 000
Skagen	7 310 000
Frederikshavn	5 166 000
Total...	17 148 000

In these amounts are not included herring from shore seines near the coast (see below).

According to Table 5 herring made up 18.8 per cent. of the weight of all the catches examined. If we use this figure in the weight amount given above, we find that 3,223,824 kg. of herring were taken as waste fish in the northern area in 1943. According to Table 7 the mean weight of the herring is 14.8 g., and so the said weight corresponds to about 218 mill. herring.

According to "Bulletin statistique" an average of about 800,000 tons of herring are taken in the North Sea, which corresponds to about 8,000 mill. herring annually. Thus we find that the 218 mill. herring of an average weight of 14.8 g. and an age of about 1 year that is removed by the Danish waste fish fishery makes only 2.7 per cent. of the number of grown-up herring caught annually in the North Sea.

In other words the removal of herring that have reached an age of about 1 year will hardly have a perceptible influence on the herring fishery of the northern area, but things are quite different at a special kind of waste fish fishery, which takes place quite close to the shore, often between the reefs near Skagen and along a great part of the Skagerak coast. This fishery is carried out by means of a special trawl or a shore seine, which takes pure herring fry at an age of a few months only and with a mean length of about 8 cm. and a mean weight of only 3—4 g. An example of such a catch is given in Table 5 and Table 7 (the southern side of Grenen, 16-VIII-1943).

It appears from the statistics of 1943 that no less than 1,058,000 kg. of these tiny herring, caught in shore seine at the coast of the Skagerak, were sold to fishmongers in Thisted alone. If we calculate how many small herring have perished in this way, we get a number of no less than 286 millions (using the figures of the said sample from Grenen), i. e. a larger number than that found to be removed by the rest of the waste fish fishery of the northern area.

Moreover these quite tiny youngs of herring have a very low percentage of fat and are therefore a poorer article than the herring otherwise taken in the waste fish fishery. It is quite evident that such a fishery is unprofitable and should be stopped. The easiest means would be to introduce a regulation of the mesh size that would allow the tiny herring fry to escape through the meshes. The introduction of a mesh size of 20 mm. in these shore seines was already proposed at the general assembly of Dansk Fiskeriforening in August 1945.

It is seen from the race analyses mentioned above that also in the southern area a considerable part of the herring examined in the samples originate from the North Sea, the Skagerak or the northern Kattegat. In part of the samples, however, there are young herring from the Belt Sea, but on the basis of the material in hand it cannot be said how great a part belongs to the local races.

In other words it has been demonstrated that in the waste fish catches from the southern area there are youngs of herring of the local races, which, as far as we know, do not make long migrations and mostly have a rather limited area of distribution, and so it is reasonable to object against an extensive waste fish fishery in these waters, more particularly because no less than 66 per cent. of the catches, according to Table 1, consist of small herring.

If we employ the same method as above for a calculation of the number of herring represented by these 66 per cent. of a total catch of 4,417,000 kg. in 1943, we find in using the statement of Table 3 that the mean weight of the herring is 16.5 g. that 177 mill. of small herring were taken as waste fish in the southern area in 1943.

The yield of the herring fishery of the southern area may be put at an annual average of about 8.3 mill. kg. With a mean of 12 herring per 1 kg. about 8.3 mill. kg. will correspond to about 100 mill. grown-up herring.

This means that the number of small herring taken away from the ordinary herring fishery by the waste fish fishery in 1943 is so great, that it exceeded the number of grown-up herring that is normally taken within this area during an average year. It is obvious that these figures must induce earnest reflections.

As mentioned above our analyses showed that part

of the small herring found in the waste fish catches of the southern area must be supposed to belong to races originating from the northern area. This would seem to indicate that the local herring races of the southern area during recent years have had a number of poor spawning years. As a matter of fact Dr. Aage J. C. Jensen in an article on the influence of the waste fish fishery on the stock of herring (Vestjysk Fiskeritidende No. 14, 24-I-1945) advocates this view and considers it the principal cause of the poor yield of the herring fishery during recent years. Experience shows that a cold winter will always be followed by a poor year-class, and it is well-known that the winters of 1939/40, 40/41 and 41/42 were extremely cold; besides, the autumn herring of the 1942 year-class also seems to have been poor in number in our inner waters. However, the author emphasizes that the waste fish fishery in the western Baltic and the Limfjord may do extensive damage to the local fishings for bigger herring and that it may decrease the stock of grown-up herring somewhat in the Belt Sea and the southern Kattegat, but Dr. Jensen does not think that the unsuccessful fishings in these two waters during recent years may be put down to this special fishery.

However, judging from what has been demonstrated above—especially the proportion between the number of young herring taken away from the ordinary herring fishery by the waste fish fishery and the number of herring normally taken in the former fishery—the present author is of opinion that an intense waste fish fishery means a considerable danger to the herring population of all our inner waters. The comparatively few race analyses carried out do not preclude the possibility of finding even considerable quantities of herring of local origin in the catches of waste fish, and at any rate it must be taken for granted that a very considerable part of the youngs of the local races will be found in the catches of waste fish in rich spawning years.

Even if it is possible—and I do not mean to deny it—that the local herring races of the southern Kattegat and the Belt Sea have had a number of poor spawning years in 1939—42 (though this cannot be proved at present), there is still a possibility that the intense waste fish fishery carried on in these waters during recent years have been a contributory cause of the unsuccessful herring fishery here during the same time. The less herring fry appearing, the greater the effect of an intense fishing for the fry.

Quite another problem concerning both the northern and the southern area is this: can the waste fish fishery perceptibly affect the nutritive conditions of our food fishes in taking away a part of their prey? The food fishes to be considered here are primarily cod, coalfish and other codfishes, but also mackerel, turbot, brill, porbeagle and others live on fishes like small whiting and small herring, which make up the majority of the waste fish catches. A Calculation shows that 238 mill. whiting were taken by this fishery in the northern and about 13 mill. in the southern area in 1943. It is very difficult—not to say impossible—to tell with certainty whether they are of any importance at all in the nutrition of our food fishes; but you must not waive the possibility that the removal of $218 + 286 + 177 = 681$ mill. herring and 251 mill. whiting means a so considerable decrease of the amount of food available to the said food fishes that it will influence their nutrition. So it is possible that the waste fish fishery will cause a poorer nutrition—and hence a slower growth—of some of our food fishes though nothing definite can be said about this.

What can be done to counteract the damaging effects of the waste fish fishery?

It is the view of many Danish fishermen and this opinion of theirs is often advanced at general assemblies and meetings that the waste fish fishery simply ought to be forbidden because it is the cause of the decrease in the yield of the herring fishery during recent years. The investigations mentioned above, however, have established the fact that as far as the North Sea, the Skagerak and the northern Kattegat are concerned there is no basis for the belief that the waste fish fishery could influence the yield of the herring fishery; but in the southern Kattegat, the Belt Sea and the western Baltic a risk is involved in an intense fishing for waste fish.

During the last 5 years the yields of the herring fishery was as follows:

The yield of the herring fishery in tons in the years 1940—44.

Year	North Sea	Skagerak	North. Kattegat	South. Kattegat	The Sound	The Belt Sea	West. Baltic	East. Baltic	Whole country
1940	301	12 644	1 363	4 090	1 242	4 207	180	4 857	29 650
1941	107	10 217	577	2 440	1 316	4 294	331	7 480	27 917
1942	55	5 479	611	1 550	519	3 721	244	7 000	19 770
1943	25	3 382	573	1 124	349	3 764	447	10 097	20 982
1944	9	3 221	919		122	4 431	721	7656	17 905

It will be seen that 1940 was a good herring year, but the yield decreased between 1941 and 1944. 1944 was a particularly poor year, in which the herring fishery may well be called unsuccessful because it yielded little more than half the catches landed in 1940.

In other words there is any reason to consider what can be done in order to counteract the damaging effects of an intense waste fish fishery in our inner waters on the stock of herring. It should be remembered, however, that the really serious rise of the waste fish fishery did not occur until 1942—43; according to information received from the Directorate of Fisheries a preliminary account of this fishery for the whole country in the year 1944 shows a yield of about 16 mill. kg., which is a distinct decrease as compared to 1942 (18.6 mill. kg.) and 1943 (23.7 mill. kg.). We thus seem to have passed the culmination, and if the decrease continues, there is of course a correspondingly smaller risk of a damaging effect on the stock of herring.

It must further be considered that during the conditions of war this country was badly in need of the oil and the fish meal that could be produced from the waste fish. It is difficult to say now how conditions will be after the war, but I think there is a reason to believe that there will still be a demand for domestic oil and fish meal, and in the following I have therefore assumed that the waste fish fishery will retain its present intensity.

In the southern area the waste fish fishery is mainly carried out with the sprat board-seine or sprat trawl (see Table 1), a fine-meshed board-seine that is dragged along comparatively rapidly, so that the gear passes lightly over the sea-floor. Outside the territorial water a "twin trawl" is often used, i. e. a trawl towed in common by two boats at some distance from each other; inside the territorial water this fishing method is prohibited by the present fisheries act. According to a notice from the ministry (22nd Dec. 1937) the mesh size of the sprat trawl is fixed at not less than 13 mm. from one knot to another, and the use of this seine is allowed only between 15th August and 31st March.

As shown by the name this gear is principally used for fishing sprat, but it cannot be avoided that large amounts of small herring are also taken in the seine. A sorting of the catch will nearly always be impossible, and quite apart from that the small herring will be dead when they come on to the deck. It is therefore no use to prohibit the landing of small herring unless such a prohibition makes the fishermen give up the catching of sprat in localities where many small herring are taken at the same time. At any rate it is certain that a total prohibition of landing and selling small herring all the year round will be a great inconvenience to the sprat fishery, and moreover a control of the observance of the prohibition will be difficult because such a total prohibition should be in force in the southern areas only.

It would seem possible to solve this problem by a regulation of the mesh size, so that the smallest herring could be sorted off. As mentioned on p. 11 an increased mesh size for shore seines was already proposed in order to prevent the absurd wasting of tiny youngs of herring in the northern area. But as far as the sprat trawl is concerned we meet with the difficulty that the sprat are saleable already at a length of about 10 cm., so that at any rate the greater part of them ought to be included in the catches. On the other hand the herring is slenderer than the sprat, so that many herring of 10 cm. or even a little more would undoubtedly pass through meshes that were made expressly to retain sprat of 10 cm., but none of smaller size. As it is now large quantities of herring of less than 10 cm. are caught (see Table 3).

In practice a regulation of mesh size that complied with the conditions mentioned above would hardly have a satisfactory effect. Firstly there is a per-

ceptible alteration of the mesh width under the use, secondly it would be very difficult to carry out an effective control.

For this reason a protection committee within the management of Dansk Fiskeriforening, supplemented with the present author, at the general meeting of Dansk Fiskeriforening on 9th August 1945 made the proposal that the use of the sprat trawl should be reduced by 1 month, so that it was allowed to use this gear only between 1st October and 15th April. It was further proposed that catches containing more than 50 per cent. of small herring (herring below grade III) must not be landed within the same period. Finally it was proposed to forbid the landing of sprat and small herring below grade III during the rest of the year. These regulations were to be valid throughout the country. An ordinance to this effect was put in force legally as from Jan. 1st, 1946.

Although it would have been desirable to have even stricter regulations concerning the use of sprat trawls and the landing of young herring, this is a step in the right direction, and it must be hailed with delight that the very organisation of the fishermen has shown the way towards a sensible solution of the problem concerning the wasting of small fishes, which in the moment of capture are of little value, but constitute the basis of one of our most important fisheries.

Tables 1–8.

Table 1. Waste fish. Analyses of catches. Southern area.

The figures represent the weight percentage of the individual species in the samples. Weight percentages of less than 0.1 are marked with a ×.

Locality	Aarhusbugten, eastern part	Aarhusbugten	Aarhusbugten Off Mols Hoved	Vejle Fjord E. of Rosenvold Hage	Holbæk	Æbelø—Fyens Hoved	Hundested	3 naut. miles E. of Mols Hoved	Aarhusbugten	Off Bogense	At Trelle Skov, Fredericia	Grenaa	Between Romsø and Sprogø	Hals	N. of Als	Gerrild off Sangstrup, Grenaa	Between Sletterhage and Isehoved	Between Romsø and Sprogø	Sønderborg	Weight percentage of the individual species in the total material
Depth in m	—	—	—	21	—	—	—	—	—	—	—	—	20—24	—	—	—	—	20—24	—	
Year	1939		1940	1941	1942		1943				1944									
Date	13/12	22/12	16/12	15/1	29/4	8/7	7/10	18/10	8/11	11/12	29/4	6/5	11/5	13/5	1/6	5/6	6/6	22/11	21/12	
Gear	S.tr.	S.tr.	S.tr.	S.tr.	Tr.	H.tr.	—	S.tr.	S.tr.	S.tr.	P.n.	—	H.tr.	P.n.	H.tr.	P.n.	S.tr.	H.tr.	—	per cent.
Whiting	60.2	..	4.0	3.5	0.5	..	41.8	1.3	4.0	0.7	..	..	10.3	..	2.5	69.4	..	14.3	29.9	14.2
Cod	1.6	..	..	..	0.7	..	..	0.1	..	..	..	..	..	..	..	..	..	3.1	1.6	0.5
Pollack	..	..	..	..	..	..	1.1	..	..	..	..	..	..	..	..	..	..	..	..	×
Dab	..	..	..	..	..	..	..	3.2	..	..	..	..	2.0	..	..	..	..	6.6	..	1.0
Long rough dab	..	..	..	..	..	..	..	0.1	..	..	..	..	..	..	..	..	..	1.1	..	0.1
Herring	36.3	82.2	67.0	92.8	26.8	99.0	0.5	71.1	80.0	82.7	100	98.0	70.0	92.7	31.3	4.8	87.5	59.6	47.5	66.0
Sprat	1.9	17.8	14.2	3.5	68.2	1.0	..	19.7	15.0	16.5	..	2.0	17.7	1.3	66.2	1.2	12.5	13.9	18.6	12.3
Mackerel	..	..	14.8	..	..	..	48.1	3.6	0.5	..	..	..	..	..	..	5.3	..	0.7	..	3.1
Horse mackerel	..	..	..	..	..	..	8.4	0.9	0.5	..	..	..	..	..	..	..	..	0.7	0.3	0.5
Sandeel	..	..	..	..	..	..	..	..	..	..	..	..	..	3.5	..	..	..	..	..	0.1
Goby	..	..	..	0.1	..	..	..	..	..	..	..	..	..	..	..	..	..	..	0.3	×
Stickleback	..	..	..	..	0.1	..	..	..	..	..	..	..	..	..	..	..	..	..	..	×
Bullhead	..	..	..	..	..	..	0.1	..	..	..	..	..	..	..	..	..	..	..	..	×
Gurnard	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	19.3	..	..	..	1.9
Cuttlefish	..	..	..	..	..	..	..	..	..	0.1	..	..	..	..	..	..	..	..	..	×
Starfish	..	..	..	..	3.7	..	..	..	..	..	..	..	..	..	..	..	..	..	0.2	0.1
Brittle star	..	..	..	0.1	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	×
Shore crab	..	..	..	..	..	..	..	..	..	..	..	..	..	2.5	..	..	..	..	..	×
Cyprina	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1.6	×
															Total of species marked with ×					0.2
																				100.0
Total weight in g.	4 013	4 000	4 000	3 997	4 105	10 000	3 985	5 276	10 000	12 090	4 000	4 000	3 000	2 000	4 000	10 370	4 000	13 250	3 055	108 141

Total 19 samples. Tr. = trawl; S.tr. = sprat trawl; H.tr. = herring trawl; P.n. = pound net.

Table 2. Measurings of whiting from catches of waste fish. Southern area.

Species	Whiting													
Locality	Eastern part of Aarhusbugten	Off Mols Hoved, Aarhusbugten	Rosenvold Hage, Vejle Fjord	Hornbæk	Hundested	3 naut. miles S. of Mols Hoved	Aarhusbugten	Bogense	Between Romsø and Sprogø	N. of Als	Gerrild off Sangstrup, Grenaa	Between Romsø and Sprogø	Sønderborg	Total number
Depth in m.	—	—	21	—	—	—	—	—	20—24	—	—	20—24	—	
Year	1939	1940	1941	1942	1943				1944					
Date	13/12	16/12	15/1	29/4	7/10	18/10	8/11	11/12	13/5	1/6	5/6	22/11	21/12	
Gear	S. tr.	S. tr.	S. tr.	Tr.	—	S. tr.	S. tr.	S. tr.	H. tr.	H. tr.	P. n.	H. tr.	—	
cm.														
6	..	..	..	..	..	..	..	..	..	..	..	..	..	..
7	..	..	..	..	..	..	..	..	..	..	..	1	2	3
8	..	..	..	..	1	..	..	..	..	..	..	..	1	2
9	..	..	..	..	..	..	..	..	..	..	..	..	5	5
10	..	..	..	1	5	1	..	..	..	..	..	..	11	18
11	..	..	..	1	13	..	..	1	..	..	..	2	13	30
12	1	1	..	..	29	2	..	..	2	..	..	6	11	52
13	6	1	..	..	18	..	..	..	4	..	2	8	10	49
14	21	2	..	..	14	1	..	..	2	..	3	4	5	52
15	21	1	..	..	14	2	..	..	3	..	15	8	..	64
16	19	..	1	..	7	1	1	..	2	..	25	5	2	63
17	15	..	1	..	5	..	..	..	..	1	30	1	1	54
18	14	..	..	..	2	..	..	..	..	..	17	2	1	36
19	9	1	1	..	5	..	..	..	..	..	9	..	..	25
20	2	..	..	..	4	..	..	..	..	..	11	1	..	18
21	1	..	..	..	6	..	..	..	..	1	11	..	..	19
22	2	..	..	..	9	1	1	..	..	..	4	..	..	17
23	7	..	..	..	9	..	..	..	..	..	3	4	..	23
24	2	..	..	..	9	1	1	..	..	..	3	..	..	16
25	6	..	..	..	12	..	1	1	..	..	..	1	..	21
26	4	..	..	..	6	..	..	..	..	..	3	1	..	14
27	3	..	..	..	1	..	..	..	..	..	..	1	..	5
28	..	..	..	..	2	..	..	..	..	..	..	..	..	2
29	..	..	..	..	4	..	..	..	..	..	..	..	..	4
30	..	..	..	..	..	..	1	..	..	..	..	..	..	1
Total...	133	6	3	2	175	9	5	2	13	2	136	45	62	593
Total-weight in g. .	7 750	160	140	20	10 000	350	—	—	310	100	7 200	1 900	910	28 840
Mean-length in cm.	17.52	—	—	—	17.08	—	—	—	13.92	—	17.93	15.64	11.60	16.62
Mean-weight in g. .	56.8	26.7	46.7	10.0	57.1	38.9	—	—	23.8	50.0	52.9	42.2	14.7	49.2

Tr. = trawl, S.tr. = sprat trawl, H.tr. = herring trawl, P.n. = pound net.

Table 3. Measurings of herring from catches of waste fish. Southern area.

Species	Herring																		
Locality	Eastern part of Aarhusbugten	Aarhusbugten	Off Mols Hoved, Aarhusbugten	Rosenvold Hage, Vejle Fjord	Holbæk	Æbelø — Fyens Hoved	Hundested	3 naut. miles S. of Mols Hoved	Bogense	Trelle Skov — Fredericia	Grenaa	Between Romsø and Sprogø	Hals	N. of Als	Gerrild off Sangstrup, Grenaa	Between Sletterhage and Isehoved	Between Romsø and Sprogø	Sønderborg	Total number
Depth i m.	—	—	—	21	—	—	—	—	—	—	—	20-24	—	—	—	—	20-24	—	
Year	1939		1940	1941	1942		1943			1944									
Date	13/12	22/12	16/12	15/1	29/4	8/7	7/10	18/10	11/12	29/4	6/5	11/5	13/5	1/6	5/6	6/6	22/11	21/12	
Gear	S. tr.	S. tr.	S. tr.	S. tr.	Tr.	H. tr.	—	S. tr.	S. tr.	P. n.	—	H. tr.	P. n.	H. tr.	P. n.	S. tr.	H. tr.	—	
cm.																			
6	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
7	..	..	..	..	..	..	..	..	..	..	..	..	1	..	..	..	..	1	2
8	1	1	..	2	..	..	..	..	1	..	..	..	5	..	..	..	..	23	33
9	..	1	..	7	..	..	..	3	4	..	..	3	90	..	..	..	..	82	190
10	3	4	..	21	10	2	..	2	4	..	..	17	84	..	..	..	4	93	244
11	5	9	4	42	13	2	..	5	12	1	26	52	35	1	..	1	9	27	244
12	23	26	5	62	23	7	..	29	40	11	53	58	15	3	..	4	26	6	391
13	28	30	24	86	32	7	..	62	57	23	48	25	9	13	..	21	74	..	539
14	29	23	30	40	13	11	..	55	23	32	32	3	3	32	..	44	89	..	459
15	30	40	36	14	3	34	..	10	1	47	20	3	..	10	1	29	25	..	303
16	42	25	4	5	..	41	1	2	..	28	7	3	..	1	..	11	2	..	172
17	11	5	7	2	..	13	..	4	..	9	6	..	..	..	5	..	..	..	62
18	10	3	8	..	..	5	2	..	..	2	3	..	..	..	..	..	..	..	33
19	1	..	2	..	..	3	..	2	..	2	3	..	..	..	1	3	..	..	17
20	..	..	..	..	..	1	..	..	..	1	..	..	..	..	2	7	..	..	11
21	..	..	..	..	..	..	..	..	..	..	1	..	..	..	2	2	..	..	5
22	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1	..	..	1
23	..	..	..	..	..	..	..	..	..	..	1	..	..	..	..	..	..	..	1
24	..	..	..	..	..	..	..	..	..	..	3	..	..	..	..	..	..	..	3
Total....	183	167	120	281	94	126	3	174	142	156	203	164	242	60	11	123	229	232	2710
Total-weight in g.....	4 000	3 290	2 680	3 710	1 100	2 700	110	3 100	2 000	4 000	3 920	1 600	1 905	1 250	500	3 500	4 000	1 450	44 815
Mean-length in (cm.).	14.47	13.89	14.51	12.44	12.36	15.28	—	13.30	12.49	14.68	13.48	11.74	10.00	13.83	18.27	14.79	13.39	9.60	12.90
Mean-weight in g.....	21.9	19.1	22.3	13.2	11.7	21.4	36.7	17.9	14.1	25.6	19.3	9.8	7.9	20.8	45.5	28.5	17.5	6.3	16.5

Tr. = trawl; S.tr. = sprat trawl; H.tr. = herring trawl; P.n. = pound net.

Table 4. Measurings of sprat from catches of waste fish. Southern area.

Locality	Eastern part of Aarhusbugten	Aarhusbugten	Off Mols Hoved, Aarhusbugten	Rosenvold Hage, Vejle Fjord	Hornbæk	Æbelø — Fyens Hoved	3 naut. miles S. of Mols Hoved	Bogense	Grenaa	Between Romsø and Sprogø	Hals	N. of Als	Gerrild off Sangstrup, Grenaa	Between Sletterhage and Isehoved	Between Romsø and Sprogø	Sønderborg	Total number
Depth in m.	—	—	—	21	—	—	—	—	—	20—24	—	—	—	—	20—24	—	
Year	1939		1940	1941	1942		1943		1944								
Date	$^{13}/_{12}$	$^{22}/_{12}$	$^{16}/_{12}$	$^{15}/_{1}$	$^{29}/_{4}$	$^{8}/_{7}$	$^{18}/_{10}$	$^{11}/_{12}$	$^{6}/_{5}$	$^{11}/_{5}$	$^{13}/_{5}$	$^{1}/_{6}$	$^{5}/_{6}$	$^{6}/_{6}$	$^{22}/_{11}$	$^{21}/_{12}$	
Gear	S. tr.	S. tr.	S. tr.	S. tr.	Tr.	S. tr.	S. tr.	S. tr.	—	H. tr.	P. n.	H. tr.	P. n.	S. tr.	H. tr.	—	
cm.																	
5	..	1	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1
6	..	2	..	..	..	..	..	..	..	..	..	..	..	..	..	9	11
7	..	2	..	3	..	..	..	..	..	5	..	..	..	..	3	18	31
8	1	23	..	1	..	..	..	4	..	13	..	6	..	..	10	53	111
9	3	19	..	..	..	..	..	21	..	37	..	91	..	6	80	39	296
10	2	6	1	5	1	..	..	11	..	18	..	109	..	17	79	5	254
11	5	2	18	7	5	..	2	2	1	3	1	51	..	8	13	1	119
12	12	10	125	..	74	..	23	7	2	..	1	10	2	2	13	..	281
13	7	5	23	..	75	4	62	1	..	..	..	13	3	5	5	..	203
14	2	6	6	1	18	..	13	..	2	..	..	4	..	3	3	..	58
15	..	1	..	..	2	..	1	..	..	..	..	..	2	2	..	..	8
Total...	32	77	173	17	175	4	101	46	5	76	2	284	7	43	206	125	1 373
Total weight in g.	450	710	2 770	140	2 800	60	2 000	385	80	530	25	2 650	120	500	1 850	570	16 720
Mean length in cm.	11.66	9.70	12.09	10.00	12.63	—	12.88	9.78	—	9.01	—	10.08	—	11.00	9.79	8.13	10.66
Mean weight in g.	14.1	9.2	16.0	8.2	16.0	15.0	19.8	8.4	16.0	7.0	12.5	9.3	17.1	11.6	9.0	4.6	12.2

Tr. = trawl; S.tr. = sprat trawl; H.tr. = herring trawl; P.n. = pound net.

Table 5. Waste f

The figures represent the weight percentage of the individual species in

Locality	N. of Skagen	NE. of Skagen	N. of Skagen	25 naut. miles NW. of Skagen Reef	1 naut. mile N. of Skagen Reef	15—20 naut. miles NW. of Skagen Reef	3 naut. miles NNW. of Skagen Reef	5 naut. miles N. of Skagen Reef	4 naut. miles SSE of Herthas Flak	N. of Skagen	9 naut. miles NE. by E. of Grenen	10-14 naut. miles NNW. of Hirts-hals	10-12 naut. miles N. by E. of Hirts-hals	10 n m N. h (Hi h
Depth i m.	c. 10	60	100	90	55	100	90	100	35—39	15—17	60	55	—	4
Year	1937			1939						1940		1941		
Date	21/8	21/8	25/8	18/7	24/7	11/8	8/9	28/9	29/11	23/4	15/10	14/4	1/2	5
Gear	P.n.	D.s.	Tr.	H. tr.	D.s.	H.tr.	H. tr.	H. tr.	H. tr.	H. tr.	H. tr.	H. tr.	Tr.	H.
Whiting	92.7	97.7	98.6	11.1	98.2	7.2	..	11.3	45.9	1.0	41.8	55.5	2.5	25
Cod	..	2.0	..	..	..	..	..	..	..	..	0.7	0.8	..	0
Haddock	..	..	..	..	..	..	..	..	..	..	1.3	1.5	..	.
Norway pout	..	..	..	58.9	0.4	21.1	..	..	..	..	17.8	0.3	..	.
Poor cod	..	..	..	..	..	..	..	..	..	..	4.3	..	..	.
Couch's whiting	..	..	..	..	..	..	..	..	..	..	..	..	..	.
Hake	..	..	..	..	..	..	..	..	..	..	..	..	..	.
Rockling	..	..	..	..	..	..	..	..	..	..	..	..	..	.
Lycodes	..	..	..	..	..	..	..	..	..	..	..	..	..	.
Lumpenus	..	..	..	..	..	..	..	..	..	..	..	..	..	.
Dab	0.1	..	1.2	..	0.2	..	..	..	..	..	..	..	..	.
Long rough dab	..	0.3	..	7.5	..	0.1	..	..	..	0.1	0.4	0.2	..	.
Pole-dab	..	..	..	..	..	..	..	..	..	..	..	..	..	.
Plaice	0.2	..	..	..	..	..	..	..	..	..	..	..	..	.
Lemon-sole	..	..	..	..	..	..	..	..	..	..	..	..	..	.
Herring	3.0	..	..	10.5	0.6	61.6	5.8	0.9	32.7	61.1	12.7	41.0	55.0	0.
Sprat	..	..	..	8.2	..	10.0	94.2	85.1	21.2	37.8	19.8	..	42.5	2.
Mackerel	0.2	..	..	..	..	..	..	2.7	..	..	0.2	0.6	..	70.
Horse mackerel	3.6	..	..	..	..	..	..	..	0.2	..	..	..	..	.
Anchovy	..	..	..	..	..	..	..	..	..	..	..	×	..	0.
Great silver smelt	..	..	..	0.6	..	..	..	..	..	..	..	..	..	.
Scopelids	..	..	..	..	..	..	..	..	..	..	..	..	..	.
Lump-sucker	..	..	..	..	..	..	..	..	..	..	..	..	..	.
Weever	0.2	..	..	..	..	..	..	..	..	..	..	..	..	.
Gurnard	..	..	0.1	..	0.3	..	..	..	..	..	..	..	..	.
Rabbitfish	..	..	..	..	..	..	..	..	..	..	..	..	..	.
Picked dogfish	..	..	..	..	..	..	..	..	..	..	..	..	..	0.
Skate	..	..	..	..	..	..	..	..	..	..	..	..	..	.
Hag	..	..	..	..	..	..	..	..	..	..	0.6	..	..	.
Cuttlefish	..	..	0.1	2.9	..	..	..	..	..	..	..	..	..	.
Swimming crab	..	..	..	..	0.1	..	..	..	..	..	..	..	..	.
Pandalus montagui	..	..	..	..	..	..	..	..	..	..	0.1	..	..	.
Hermit-crab	..	..	..	..	..	..	..	..	..	..	0.3	..	..	.
Norway lobster	..	..	..	..	..	..	..	..	..	..	..	..	..	.
Common starfish	..	..	..	..	0.2	..	..	..	..	..	..	0.1	..	.
Jellyfish	..	..	..	0.3	..	..	..	..	..	..	..	..	..	.
Other invertebrates	..	..	..	..	..	..	..	..	..	..	..	..	..	.
Total weight...	19 420	19 450	20 310	17 150	15 790	13 285	10 400	7 520	8 715	51 570	9 810	41 435	4 000	45 1

Tr. = trawl; H.tr. = herring trawl; D.s. = Danish seine; P.n. = pound net.

thern area.

les examined. Weight percentages of less than 0.1 are marked with a ×.

	Sæby	20 naut. miles NNW. of Skagen	NE. of water tower of Skagen	Southern side of Grenen	15 naut. miles N. of Hirtshals	15 naut. miles N. of Hirtshals	8 naut. miles WNW. of Hirtshals	Frederikshavn	8 naut. miles WNW. of Hirtshals	Skagen	8 naut. miles WNW. of Hirtshals	Skagen	15 naut. miles N. by E. of light buoy at Grenen	Off Højen lighthouse close to the shore	Hirtshals	Weight percentage of the individual species in the total material
	—	100	36	ca. 15	75	50	50	—	50	—	50	—	210	—	—	
	1941			1943				1944								
	17/2	7/3	3/5	16/8	23/8	13/9	26/10	14/1	15/2	26/2	26/2	20/4	1/5	3/10	18/12	
	—	H. tr.	H. tr.	H. tr.	Tr.	Tr.	D.s.	—	D.s.	—	D.s.	—	Tr.	Tr.	—	per cent.
	85.6	77.9	84.2	..	57.5	70.0	60.5	1.3	86.4	98.0	82.0	65.8	58.2	89.3	75.6	52.9
	0.6	0.6	8.4	..	..	..	19.8	0.3	2.3	1.0	0.3	6.6	..	0.1	1.6	1.5
	..	..	..	..	..	..	0.4	..	0.9	..	1.0	0.8	..	5.8	..	0.4
	..	7.2	..	..	18.3	..	..	..	..	..	..	0.3	..	..	..	3.8
	..	..	..	..	..	5.0	3.3	..	0.3	0.2	0.2	5.9	0.5	1.2	..	0.5
	..	..	..	..	..	..	..	..	..	..	..	..	16.2	..	..	0.6
	..	1.2	..	..	..	..	..	..	..	..	..	0.1	2.5	..	..	0.1
	..	4.0	..	..	0.7	..	..	..	..	..	..	..	10.5	..	..	0.5
	..	0.2	..	..	..	..	..	..	..	..	..	..	0.6	..	..	×
	0.1	..	..	..	..	..	..	..	..	..	..	..	..	..	..	×
	..	1.6	2.0	..	..	..	10.7	..	3.3	0.1	0.7	1.7	..	..	6.0	0.8
	..	5.3	2.6	..	7.8	5.0	4.1	..	..	..	1.3	18.3	..	..	..	1.5
	..	..	..	..	..	..	..	..	..	..	..	..	5.2	..	..	0.2
	..	..	..	..	..	..	..	..	..	..	0.5	..	..	..	0.9	0.1
	..	..	1.0	..	..	..	..	..	..	..	..	..	..	..	..	×
4	7.3	0.8	..	100.0	15.0	10.0	..	95.2	4.0	0.1	8.5	..	..	..	15.9	18.8
9	4.1	..	0.1	..	0.1	..	..	3.2	0.1	..	0.2	..	..	..	..	10.4
2	1.3	..	..	..	..	..	..	..	..	..	0.2	..	..	..	..	6.4
	..	..	..	..	..	..	..	..	..	..	..	..	..	2.6	..	0.2
	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	×
	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	×
	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	×
	..	..	..	..	..	10.0	..	..	..	..	..	..	..	..	..	0.2
	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	×
	..	..	1.4	..	..	..	0.7[1]	..	2.7	0.5	2.5	0.5	..	0.4	..	0.4
	..	..	..	..	..	..	..	..	..	..	..	..	6.3	..	..	0.2
	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	×
	..	..	..	..	..	..	..	..	..	..	2.1	..	..	..	..	0.1
	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	×
	0.3	..	..	..	..	..	..	..	..	..	..	..	..	..	..	0.1
	..	..	..	..	..	..	..	..	..	..	0.1	..	..	0.3	..	×
	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	×
	0.5	..	..	..	..	..	..	..	..	..	..	..	..	..	..	×
	..	..	..	..	0.6	..	..	..	..	..	..	..	..	..	..	×
	0.2	..	..	..	..	..	..	..	..	0.1	0.4	..	..	0.3	..	×
	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	×
	..	1.2	0.3	..	..	..	0.5	..	..	..	..	..	..	..	..	×
0	11 000	12 320	14 820	1 000	20 000	8 000	18 175	4 000	19 685	20 000	32 935	11 470	19 090	8 615	4 100	514 230

? of them *Triglops pingelii*.

Total weight of the species marked with ×: 0.3 per cent.

Table 6. Measurings of whiting fro

Locality	N. of Skagen	NE. of Skagen	Skagen	25 naut. miles NW. of Skagen Reef	1 naut. mile N. of Skagen Reef L. V.	15-20 naut. miles NE. of Skagen Reef L. V.	5 naut. miles N. of Skagen Reef	4 naut. miles SSE. of Herthas Flak	9 naut. miles NE. by E. of Grenen	Channel 10-14 naut. miles NNW. of Hirtshals	10-12 naut. miles N. by E. of Hirtshal
Depth in m.	c. 10	c. 60	c. 100	90	55	—	100	35—39	60	55	—
Year	1937			1939					1940		
Date	$^{21}/_{8}$	$^{21}/_{8}$	$^{25}/_{8}$	$^{18}/_{7}$	$^{24}/_{7}$	$^{11}/_{8}$	$^{28}/_{9}$	$^{29}/_{11}$	$^{15}/_{10}$	$^{14}/_{1}$	$^{1}/_{2}$
Gear	P.n.	D.s.	Tr.	H.tr.	D.s.	H.tr.	H.tr.	H.tr.	H.tr.	H.tr.	Tr.
cm.											
6	..	..	..	..	..	..	..	..	..	..	..
7	..	..	..	1	..	..	..	..	..	..	..
8	..	..	..	4	..	..	..	2	4	..	1
9	..	..	..	1	..	..	..	1	5	..	..
10	..	2	..	..	..	..	..	2	9	..	..
11	..	3	14	..	..	..	..	3	19	1	..
12	..	8	29	..	..	..	..	9	19	8	..
13	..	3	18	..	..	..	1	17	9	25	..
14	..	2	5	..	..	..	..	20	3	54	..
15	..	1	2	..	1	..	..	14	2	38	1
16	1	1	8	..	4	..	..	11	1	23	..
17	2	6	8	..	12	..	..	12	1	10	..
18	9	13	37	..	14	1	..	5	..	3	..
19	20	15	47	..	20	..	..	7	1	2	1
20	38	26	36	..	38	..	..	3	..	2	..
21	20	14	23	1	42	1	1	2	2	1	..
22	8	8	9	1	21	1	1	9	1	..	..
23	2	8	7	2	28	3	4	3	..	1	..
24	2	5	..	3	15	1	1	6	..	..	..
25	..	6	2	..	4	1	..	..	..	..	..
26	..	6	1	3	1	2	..	1	..	..	..
27	..	5	1	3	..	..	..	..	..	..	..
28	..	1	1	2	..	..	..	..	..	..	..
29	..	1	..	..	1	..	..	..	..	..	..
30	..	..	..	..	..	..	..	..	..	..	..
31	..	..	..	..	..	..	..	..	..	..	..
32	..	..	..	..	..	..	..	..	..	..	..
33	..	..	..	..	..	..	..	..	..	..	..
34	..	..	..	..	..	..	..	..	..	..	..
35	..	..	..	..	..	..	..	..	..	..	..
36	..	..	..	..	..	..	..	..	..	..	..
37	..	..	..	..	..	..	..	..	..	..	..
Total...	102	134	248	21	201	10	8	127	76	168	2
Total weight in g.	—	—	—	1 900	15 500	960	850	4 000	1 300	5 000	100
Mean length in cm.	20.02	19.85	17.23	20.76	20.79	23.10	—	16.06	11.96	14.69	—
Mean weight in g.	—	—	—	90.5	77.1	96.0	106.3	31.5	17.1	29.8	50.0

Tr. = trawl; H.tr. = herring trawl; D.s. = Danish seine; P.n. = pound net.

tches of waste fish. Northern area.

ank 10 naut. miles . by E. of irtshals	Sæby	20 naut. miles NNW. of Skagen	NE. of water tower of Skagen	15 naut. miles N. of Hirts-hals	8 naut. miles WNW. of Hirts-hals	Frede-riks-havn	8 naut. miles WNW. of Hirts-hals	Skagen	8 naut. miles WNW. of Hirts-hals	Skagen	15 naut. miles N. by E. of light buoy Grenen	Off Højen light-house close to the shore	Hirts-hals	Total number
40	—	100	36	75	50	—	50	—	50	—	210	—	—	
1941				1943		1944								
$^{5}/_{2}$	$^{17}/_{2}$	$^{7}/_{3}$	$^{3}/_{5}$	$^{23}/_{8}$	$^{26}/_{10}$	$^{14}/_{6}$	$^{15}/_{2}$	$^{26}/_{2}$	$^{26}/_{2}$	$^{20}/_{4}$	$^{1}/_{5}$	$^{3}/_{10}$	$^{18}/_{12}$	
H.tr.	—	H.tr.	H.tr.	Tr.	D.s.	—	D.s.	—	D.s.	—	Tr.	Tr.	—	
..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
..	..	..	..	4	1	..	..	..	..	..	..	..	..	6
..	..	..	..	14	3	..	..	..	..	..	..	3	..	30
..	..	..	..	18	10	..	..	..	1	..	..	4	3	43
..	4	..	..	26	14	..	..	..	..	..	..	8	13	78
..	17	2	..	19	27	..	..	..	1	3	1	15	14	139
1	22	4	6	4	56	..	2	1	4	6	..	39	14	232
6	29	20	20	4	71	1	5	6	14	11	..	32	26	318
17	43	38	38	1	52	2	9	5	34	42	2	7	31	405
29	32	72	33	..	41	..	16	7	56	54	5	1	17	422
25	10	68	27	..	33	..	18	15	57	28	7	1	16	354
17	5	60	27	..	9	..	19	10	44	14	10	..	12	278
16	3	12	26	..	3	..	14	6	55	16	9	..	3	245
9	..	8	35	2	1	..	10	7	38	15	8	..	1	247
6	1	5	24	1	1	..	8	1	13	3	9	1	..	216
4	2	5	19	3	4	..	7	5	11	..	4	..	..	171
1	1	2	14	..	5	..	7	6	9	3	4	1	..	112
2	2	..	2	3	6	..	3	5	15	1	3	1	..	101
5	..	..	2	1	3	..	6	2	10	1	1	1	..	65
5	..	..	1	2	5	..	4	2	7	..	..	..	..	39
2	..	..	..	5	1	..	5	2	4	2	..	..	..	35
3	..	..	..	5	5	..	2	6	7	1	..	..	..	38
3	..	..	..	7	1	..	2	1	1	1	..	..	..	20
3	..	..	..	3	..	..	2	2	1	..	..	..	..	13
1	..	..	..	7	..	..	1	..	..	..	..	..	..	9
2	..	..	..	8	..	..	..	1	1	..	..	..	..	12
1	..	..	..	2	1	..	..	..	1	..	..	..	..	5
..	..	..	..	..	1	..	..	1	..	..	..	..	..	2
..	..	..	..	..	..	..	..	..	1	..	..	..	..	1
1	..	..	..	1	..	..	..	..	..	..	..	..	..	2
..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
..	..	..	..	..	..	..	..	..	..	1	..	..	..	1
159	171	296	274	140	354	3	140	91	385	202	63	114	150	3639
11 500	4 100	9 600	12 450	9 040	11 000	50	8 500	7 000	20 000	7 550	3 100	2 000	3 100	138 600
18.18	13.90	15.77	17.11	16.10	14.27	—	18.64	19.23	17.75	15.95	18.33	12.34	13.59	16.63
72.3	24.0	32.4	45.4	64.6	31.1	16.7	60.7	76.9	51.9	37.4	49.2	17.5	20.7	43.9

Table 7. Measurings of herring from

Locality	N. of Skagen	25 naut. miles NW. of Skagen Reef	1 naut. mile N. of Skagen Reef L.V.	3 naut. miles NNW. of Skagen Reef L.V.	5 naut. miles N. of Skagen Reef L.V.	4 naut. miles SSE. of Herthas Flak	N. of Skagen	9 naut. miles NE. by E. of Grenen	Channel N. by E. of Hirtshals	10—12 naut. miles N. by E. of Hirtshals
Depth in m.	c. 10	90	55	90	100	35—39	15—17	60	55	—
Year	1937	1939					1940		1941	
Date	$^{21}/_{8}$	$^{18}/_{7}$	$^{24}/_{7}$	$^{8}/_{9}$	$^{28}/_{9}$	$^{29}/_{11}$	$^{23}/_{4}$	$^{15}/_{10}$	$^{14}/_{1}$	$^{1}/_{2}$
Gear	P.n.	H.tr.	D.s.	H.tr.	H.tr.	H.tr.	H.tr.	H.tr.	H.tr.	Tr.
cm.										
5	..	..	..	..	..	..	..	..	..	..
6	..	..	..	..	..	..	..	..	..	..
7	..	..	..	..	..	..	..	..	..	..
8	..	..	..	..	..	2	..	6	..	1
9	..	..	..	..	..	6	..	9	..	1
10	..	1	..	..	..	24	1	7	..	6
11	..	8	..	..	..	33	5	12	7	14
12	2	2	..	1	..	22	13	19	32	16
13	..	6	..	..	..	5	41	12	50	16
14	12	5	..	1	..	12	41	7	31	6
15	6	19	..	3	..	6	65	10	11	1
16	4	21	..	4	..	6	35	3	3	3
17	1	2	1	7	1	1	12	1	..	3
18	1	1	1	..	1	..	12	..	..	5
19	1	..	..	1	..	..	4	..	..	3
20	..	..	..	..	..	..	1	..	..	2
21	..	..	..	..	..	..	..	..	..	5
22	..	..	..	..	..	..	..	..	..	2
Total...	27	65	2	17	2	117	230	86	134	84
Total weight in g.	—	1 800	100	600	—	1 500	5 000	1 250	2 000	2 200
Mean length in cm.	14.81	14.51	—	16.06	—	11.74	14.69	11.95	13.12	13.87
Mean weight in g.	—	27.7	50.0	35.3	—	12.8	21.7	14.5	14.9	26.2

Tr. = trawl; H.tr. = herring trawl; D.s. = Danish seine; P.n. = pound net.

ches of waste fish. Northern area.

Bank naut. iles N. E. of rtshals	7-8 naut. miles N. by W. of Hirtshals	20 naut. miles NNW. of Skagen	8-10 naut. miles NW. of Hirtshals	Southern side of Grenen	15 naut. miles N. of Hirtshals	15 naut. miles N. of Hirtshals	Frederikshavn	8 naut. miles WNW. of Hirtshals	Skagen	8 naut. miles WNW. of Hirtshals	Hirtshals	Total number
40	—	100	50—60	c. 15	c. 75	50	—	50	—	50	—	
	1941				1943			1944				
$^{5}/_{2}$	$^{15}/_{2}$	$^{7}/_{3}$	$^{20}/_{3}$	$^{16}/_{8}$	$^{23}/_{8}$	$^{13}/_{9}$	$^{14}/_{1}$	$^{15}/_{2}$	$^{26}/_{2}$	$^{26}/_{2}$	$^{18}/_{12}$	
H. tr.	Tr.	H. tr.	Tr.	Tr.	Tr.	Tr.	—	D. s.	—	D. s.	—	
..	..	..	..	..	..	..	2	..	..	..	..	2
..	..	..	..	17	..	..	..	..	..	..	..	17
..	4	..	..	86	..	..	2	..	..	..	..	92
..	1	..	..	76	..	..	10	..	..	..	..	96
..	2	..	..	67	..	1	25	..	..	..	18	129
1	5	..	1	18	1	10	52	5	..	4	51	187
2	31	..	..	2	3	1	47	18	..	9	12	204
1	97	..	2	1	1	..	42	22	..	30	1	304
4	56	..	10	..	18	..	16	21	2	47	1	305
..	20	..	16	..	58	..	..	..	..	35	..	244
1	9	..	25	..	45	1	..	..	..	20	2	224
2	13	..	50	..	4	3	..	..	..	7	..	158
1	5	1	98	..	3	1	..	..	..	12	..	150
..	4	..	144	..	1	..	..	..	..	1	..	171
..	3	..	108	..	..	..	..	..	..	3	..	123
..	..	..	87	..	..	..	..	..	..	..	..	90
..	..	1	31	..	..	..	..	..	..	..	..	37
..	..	..	2	..	1	..	..	..	..	..	..	5
12	250	2	574	267	135	17	196	66	2	168	85	2 538
250	3 800	100	—	1 000	3 000	175	1 700	790	20	2 810	650	28 545
13.33	12.70	—	17.96	7.97	14.30	11.76	10.60	11.89	—	13.64	10.01	13.05
20.8	15.2	50.0	—	3.7	22.2	10.3	8.7	12.0	10.0	16.7	7.6	14.8

Table 8. Measurings of sprat from catches of waste fish. Northern area.

Locality	25 naut. miles NW. of Skagen Reef	3 naut. miles NNW. of Skagen Reef L.V.	5 naut. miles N. of Skagen Reef L.V.	4 naut. miles SSE. of Herthas Flak	N. of Skagen	9 naut. miles NE. by E. of Grenen	10—12 naut. miles N. by E. of Hirts-hals	Bank 10 naut. miles N. by E. of Hirts-hals	7—8 naut. miles N. byW. of Hirts-hals	8—10 naut. miles NW. of Hirts-hals	NE. of water tower of Skagen	15 naut. miles N. of harbour of Hirts-hals	Frede-riks-havn	8 naut. miles WNW. of Hirts-hals	Total number
Depth in m.	90	90	100	35—39	15—17	60	—	40	—	50—60	36	c. 75	—	50	
Year	1939				1940		1941					1943	1944		
Date	$^{18}/_{7}$	$^{8}/_{9}$	$^{28}/_{9}$	$^{29}/_{11}$	$^{23}/_{4}$	$^{15}/_{10}$	$^{1}/_{2}$	$^{5}/_{2}$	$^{15}/_{2}$	$^{20}/_{3}$	$^{3}/_{5}$	$^{23}/_{8}$	$^{14}/_{1}$	$^{26}/_{2}$	
Gear	H. tr.	H. tr.	H. tr.	H. tr.	H. tr.	H. tr.	Tr.	H. tr.	Tr.	Tr.	H. tr.	Tr.	—	D. s.	
cm.															
6	..	..	..	..	..	..	..	..	1	..	..	..	..	..	1
7	..	..	..	1	..	..	..	14	4	..	..	..	1	..	20
8	..	..	..	3	..	7	..	28	9	..	..	..	6	..	53
9	..	..	6	4	..	18	11	37	3	..	..	..	..	..	79
10	8	60	70	14	..	22	36	30	..	2	..	..	7	..	249
11	19	125	89	31	4	17	40	20	1	4	..	1	5	1	357
12	16	35	25	37	25	3	22	10	1	6	..	..	..	1	181
13	23	9	7	27	60	21	17	1	2	7	..	..	..	1	175
14	6	1	4	8	45	20	6	1	3	4	..	..	..	..	98
15	2	..	..	6	14	14	3	..	1	1	1	..	..	1	43
16	..	..	..	2	16	2	..	..	..	..	..	..	..	..	20
Total...	74	230	201	133	164	124	135	141	25	24	1	1	19	4	1276
Total weight in g.	—	2 600	1 400	1 850	—	1 930	1 700	1 000	200	—	20	10	130	60	10 900
Mean length in cm.	12.08	10.98	10.85	11.86	13.54	11.76	11.21	9.30	9.56	12.42	—	—	9.47	—	11.35
Mean weight in g.	—	11.3	7.00	13.9	—	15.6	12.6	7.1	8.0	—	20.0	10.0	6.8	15.0	10.7

Tr. = trawl; H.tr. = herring trawl; D.s. = Danish seine.

Investigations on the Danish Fishery for and the Biology of the Norway Lobster and the Deep-Sea Prawn.

By

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Preface.

Findings of fishing gears and remains of fishes in the refuse heaps from the neolithic age shows us that fishing has been going on in Danish waters through thousands of years and that our people has found wholesome and nourishing food and a valuable article of trade in the abundance of the sea in fishes and other utility animals. Throughout this long period an ever intenser fishery has been carried on. Boats and gears grew better and better simultaneously with a rapid growth of the possibilities of utilizing the catches. Especially with the introduction of motor power about 30 years ago this has brought about such an exhaustion of the stocks of fishes and utility animals, that the idea of the "profusion of the sea" now belongs to history.

During the present century we have learned several times that some stock of fish could not sustain the ever increasing fishery; in spite of an intensified use of gears the yield of the fishery decreased year by year. Consequently it has been necessary in view of the continued thriving of the stocks to introduce regulations of protection, which, however, necessary they were to the stock of fish and hence to the future of the fishery, meant a considerable restriction of the fishing.

The fishermen themselves have realized the necessity of these protective regulations, and at the same time they have understood how to find compensation for the possibilities that have been restrained by the protection. Firstly the fishermen have tried to find new fishing grounds further seawards, secondly they have tried to utilize fishes or other marine animals that were no objects of fishery in former times. Such species as dab and sprat, which formerly were almost without importance to the fishery, have now become more and more prominent, especially during the period between the two great wars.

The importance of such new fisheries lies not only in the fact that they compensate for the losses suffered through the reduction of the stocks of the "old" utility fishes, e. g. plaice, but also in the fact that the stocks of these old utility fishes are protected to a considerable degree when the energy of the fishermen is devoted to other aims. Every time a fishermen of the Belt Sea is trawling for sprat instead of fishing for plaice he contributes to the protection of the threatened plaice population.

Among the newest fisheries that have arisen in our times are the fisheries for Norway lobster and deep-sea prawn.

The Norway Lobster.

Introduction.

The Norway lobster, Danish Dybvandshummer (*Nephrops norvegicus* L.) or the "maiden lobster" as it is also called on account of its slender shape is a close relation of the common lobster. It is easily distinguished from the latter by the comparatively slender, and very thorny claws and by its reddish-yellow colour (unlike the common lobster it does not change its colour when cooked). At the upper side of the abdomen there are some furrows with brown hairs in them; these furrows, the shape of which bears some resemblance to angular letters, have given the animal its Norwegian name of "Bogstavhummer"

Figure 1. The distribution of the Norway lobster in the waters round Danmark. ● denotes places where adult individuals and ○ places outside the proper area of distribution where larvae were caught during experimental fishings from the research vessels "Thor", "Dana" and "Biologen" in the years 1903—39; within the area with double hatching the places of capture are so closely situated, that they could not be given separately. ÷ denotes the deep area of the Skagerak where no Norway lobsters were observed.

("letter lobster"). The Swedish name is "Havskräfta" or "Kajsarhummer" ("sea lobster" or "emperor lobster").

The Norway lobster attains a length of up to 45 cm., at which size it weighs about 1 kg.; in other words it does not nearly reach the same length as the common lobster.

The common lobster is found only in shallow water, principally at depths between 10 and 40 m., whereas the home of the Norway lobster is the somewhat greater depths between about 30 and about 200 m., that is to say: it lives within the area of the soft bottom.

Its area of distribution stretches along the western coast of Europe from the Mediterranean to North Cape; besides it lives at the Faroes and at Iceland. It thus lives further northwards than the common lobster, which is found neither at the north of Norway nor at the Faroes and Iceland.

Occurrence.

The map (Figure 1) shows the areas within the waters round Denmark where Norway lobsters were taken during the scientific fishing experiments made by the Danish Biological Station and the Danish Commission for Fisheries Investigations and the Study of the Sea.

The Norway lobster is found principally at depths between 30 and 200 m.; once it was taken at so shallow water as 17 m., in Aalbæk Bugten in the northern Kattegat; the greatest depth at which it was taken is 240 m. in the Skagerak.

In Danish waters the distribution of the Norway lobster falls within 3 main areas, the principal of which is the northern Kattegat outside the depth of about 30 m. between Skagen, Læsø and the coast of Sweden with the adjacent parts of the eastern Skagerak between 40 and about 200 m. To the west in the Skagerak it is found within a narrow area between 50 and 200 m. depth from N. of Hirtshals to W. of Hanstholm, from which place the area of occurrence continues into the northeastern North Sea. In the eastern Kattegat it is found southwards across a narrow strip in the 40—60 deep channel of the eastern Kattegat E. of Læsø, Kobbergrunden and Anholt.

S. of Anholt the deepwater area widens a little forming a basin between Anholt, Schultz's Grund, the north coast of Seeland and the west coast of Sweden, with depths between about 30 and 40 m. This vast area with its soft bottom is the second habitat of the Norway lobster, and here it is found in rather large numbers though not so numerously as in the northern Kattegat and the eastern Skagerak.

A third area of occurrence is found in the eastern North Sea between the Dogger Bank and the Horns Reef Area where the Norway lobster occurs in large quantities outside the 40 m. curve.

The Norway lobster lives in places where the bottom is soft, so that it can bury itself in the ooze of the bottom where it finds its nourishment and hides from its enemies. One of the worst enemies of the Norway lobster—apart from man—is the cod; in the stomachs of the big cod we very often find remains of Norway lobsters: such remains were found in 6 out of 9 big cod caught at 45 m. depth W. of the Horns Reef. Also in the northern Kattegat and the Skagerak the Norway lobster constitutes a considerable part of the food of the big cod.

The inner limits of the normal habitat of the Norway lobster in this country are found in the western Kattegat at the Schultz's Grund and at the northern entrance of the Sound; it was taken once in the northern Sound immediately N. of Hven.

Areas of more than 30 m. depth and with soft bottom are also found further southwards in Danish waters and so it is undoubtedly the decreasing salinity that determines the southern limit of the advance of the Norway lobster in Danish waters. At the said inner limits the salinity of the bottom water is 29—30 ‰; at the Schultz's Grund L.V. in the southwestern corner of the Kattegat the mean salinity of the bottom water (26 m.) for all months of the year is 30.6 ‰ (the period 1903—26), the monthly variation within the same period being 29.2—32.4 ‰. At the Lappegrundens L.V. the corresponding figures from 23 m. depth are 31.1 ‰ (29.6—32.5 ‰)[1]). In other words we must take a salinity of about 29—30 ‰ to be the lowest at which the Norway lobster is able to live.

The tiny fry (larvae at the younger schizopod-stage), which live pelagically, are carried outside the habitat of the adult individuals by the marine currents; this tiny fry has been found as far southwards as the northern Belt Sea, in the deep channel between Sejrø and Samsø (see the open circles on the map Figure 1).

Size and growth.

The Norway lobster does not by far reach the same size as the common lobster. The prevalent size of the common lobster is 23—35 cm., but Norway lobsters of more than about 22 cm. in length are rarely caught, and the ordinary size of the Norway lobsters that are brought into the market varies between about 14 and 20 cm.

On the basis of the measurements given in Tables 1 and 2 Figure 2 shows the distribution as to lentgh (for males + females) of the Norway lobsters taken in the northern Kattegat and the eastern Skagerak in the years 1935—39 partly by the commercial fishermen (the full graph), partly during the fishing experiments of the Biological Station with the fine-meshed eel-seine (the dotted graph).

The graphs go from 8 to 25 cm. A common feature of both graphs is the very small number of individuals of more than 20 cm. Individuals of more than 25 cm. did not occur at all in the samples measured, and Norway lobsters of more than 25 cm. must therefore be considered very rare. The graph representing the analyses of catches from the commercial fishery has a maximum at 16 cm. while the graph showing the catches with the eel-seine has a maximum at 13—14 cm. The mean length of 569 individuals taken in

[1]) Mean Values of Observations from Danish Light-Vessels. Nautisk-meteorologisk Aarbog. 1932. Copenhagen 1933.

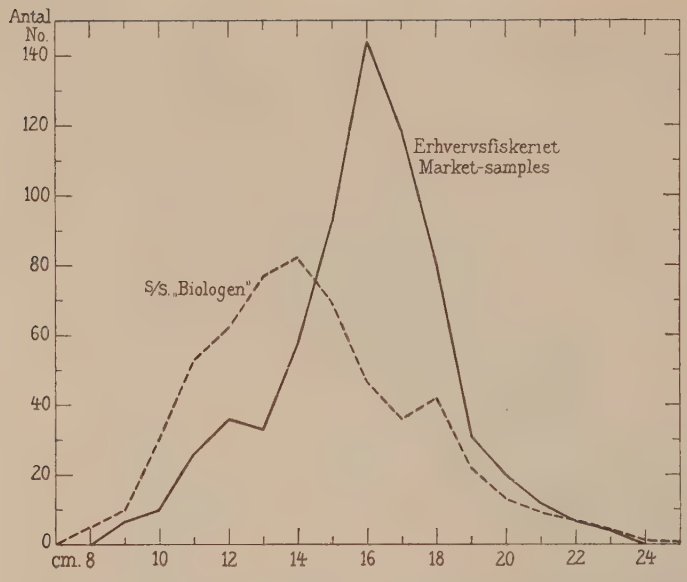

Figure 2. Lengths of Norway lobsters (male + females) caught in the Skagerak and the northern Kattegat by commercial fishermen (trawl) and by scientific fishing experiments from S/S "Biologen" (eel-seine).

the eel-seine is 14.4 cm., the mean length of 679 individuals from the commercial fishery is 15.8 cm. or $1^1/_2$ cm. higher. The cause of this difference in length is of course that the gears used in the commercial fishery has a much wider mesh (about 34—52 mm. mesh size in the bag) than the eel-seine (mesh size from knot to knot 15—18 mm.). None of the Norway lobsters from the commercial fishery were less than 9 cm. in length, and none of those from the eel-seine were less than 8 cm. It is a surprising fact that no individuals of less than 8 cm. were taken in the eel-seine because such individuals could easily be retained by the fine meshed gear, which often takes for instance lots of shrimps of 4—7 cm. in length. At present we do not know very much about the biology or the habitat of the youngs of the Norway lobster. The fact that the growing youngs are not taken in the eel-seine seems to indicate that

Table 1. Total length (from the point of the rostrum to the hind edge of the telson) of Norway Lobster caught in the northern Kattegat and eastern Skagerak during fishing experiments with the Eeltog in the years 1935—38.

Date	July 1935			August 1935			August 1937			June-Aug. 1938			Total				
	Males	Females without eggs	Berried Females	Males	Females without eggs	Berried Females	Males	Females without eggs	Berried Females	Males	Females without eggs	Berried Females	Males	Females without eggs	Berried Females	Females total	Males and Females total
cm.																	
8	..	2	..	..	2	..	..	..	..	..	1	..	..	5	..	5	5
9	1	2	..	2	5	..	..	..	..	..	..	..	3	7	..	7	10
10	8	4	..	4	9	..	..	..	..	2	3	..	14	16	..	16	30
11	8	8	..	11	11	..	..	..	..	7	8	..	26	27	..	27	53
12	12	11	..	20	14	..	1	..	..	2	2	..	35	27	..	27	62
13	26	5	..	19	20	..	1	..	..	4	2	..	50	27	..	27	77
14	30	7	1	18	12	..	2	..	..	11	..	..	61	19	1	20	81
15	25	3	..	17	7	..	3	..	..	14	..	..	59	10	..	10	69
16	21	3	..	6	4	..	4	1	..	7	1	..	38	9	..	9	47
17	11	1	..	7	..	..	10	..	..	7	..	..	35	1	..	1	36
18	17	..	..	6	..	..	11	..	..	8	..	..	42	..	..	..	42
19	6	..	..	3	..	..	5	..	..	8	..	..	22	..	..	..	22
20	10	..	..	..	..	..	3	..	..	..	..	..	13	..	..	..	13
21	5	..	..	1	..	..	2	..	..	1	..	..	9	..	..	..	9
22	2	..	..	3	..	..	1	..	..	1	..	..	7	..	..	..	7
23	2	..	..	2	..	..	..	..	..	..	..	..	4	..	..	..	4
24	..	..	..	1	..	..	..	..	..	..	..	..	1	..	..	..	1
25	..	..	..	1	..	..	..	..	..	..	..	..	1	..	..	..	1
Total...	184	46	1	121	84	0	43	1	0	72	17	0	420	148	1	149	569
Mean length[1])	15.2	12.3	14.0	14.3	12.3	..	17.4	16.0	..	15.4	11.3	..	15.2	12.3	14.0	12.3	14.4

[1]) As the individuals are measured down to the nearest whole cm., the actual mean length is 0.5 cm. higher than the figures here show.

Table 2. Total length (from the point of the rostrum to the hind edge of the telson) of Norway Lobster caught in the northern Kattegat and eastern Skagerak during market fishing in the years 1935—39.

Date	27-4-1935			18-6-1935			10-11-1937			28-11-1937			10-12-1939			Total				
	Males	Females without eggs	Berried Females	Males	Females without eggs	Berried Females	Males	Females without eggs	Berried Females	Males	Females without eggs	Berried Females	Males	Females without eggs	Berried Females	Males	Females without eggs	Berried Females	Females total	Males and Females total
cm																				
9	2	2	..	..	..	..	..	..	..	3	..	..	..	..	..	5	2	..	2	7
10	1	2	..	2	1	..	..	..	..	3	1	..	..	..	..	6	4	..	4	10
11	6	4	..	3	10	..	..	..	..	2	1	..	..	..	..	11	15	..	15	26
12	19	1	..	5	6	3	..	..	..	2	..	..	..	..	..	26	7	3	10	36
13	13	3	..	4	3	3	..	..	..	5	2	..	..	..	..	22	8	3	11	33
14	18	3	..	19	4	3	4	..	..	7	..	..	..	..	..	48	7	3	10	58
15	19	5	..	30	..	4	13	3	1	7	4	..	5	..	2	74	12	7	19	93
16	6	6	..	26	5	16	44	17	..	8	2	..	6	4	4	90	34	20	54	144
17	7	..	..	17	7	7	37	26	2	4	1	..	7	3	..	72	37	9	46	118
18	14	..	..	15	3	1	27	10	1	5	1	..	3	..	..	64	14	2	16	80
19	3	..	..	5	..	1	18	..	..	3	1	..	..	..	..	29	1	1	2	31
20	2	..	..	1	..	..	9	1	..	7	..	..	..	..	..	19	1	..	1	20
21	1	..	..	1	..	..	6	..	..	4	..	..	..	..	..	12	..	..	..	12
22	..	..	..	1	..	..	..	..	..	6	..	..	..	..	..	7	..	..	..	7
23	2	..	..	1	..	..	..	..	..	1	..	..	..	..	..	4	..	..	..	4
Total...	113	26	0	130	39	38	158	57	4	67	13	0	21	7	6	489	142	48	190	679
Mean length.	14.7	13.3	..	15.7	13.9	15.5	17.2	16.7	16.8	16.3	14.9	..	16.4	16.4	15.7	16.0	15.2	15.6	15.3	15.8

they are living so deeply buried in the bottom and appearing so rarely, that there is no great chance of the gear catching them. It is well-known that the adult Norway lobster hides in the bottom, and although no such thing has been demonstrated about the growing youngs, there is hardly any reason to doubt that they will also hide in the soft sea-floor. However, there is a possibility that the lack of youngs in the eel-seine catches may mean that the youngs are living in other localities than the grown-up individuals, viz. on stony bottom where the eel-seine or other seines cannot be used.

Several authors[1]) have called attention to the fact that there is some difference in size between males and females; according to Havinga (l. c.) the males attain a length of 22 cm., the females a length of only 17 cm.

In the Danish material there is a distinct difference in size between the two sexes. Figure 3 is a graphical representation of the length of males and females (berried as well as not berried) in the material (un-

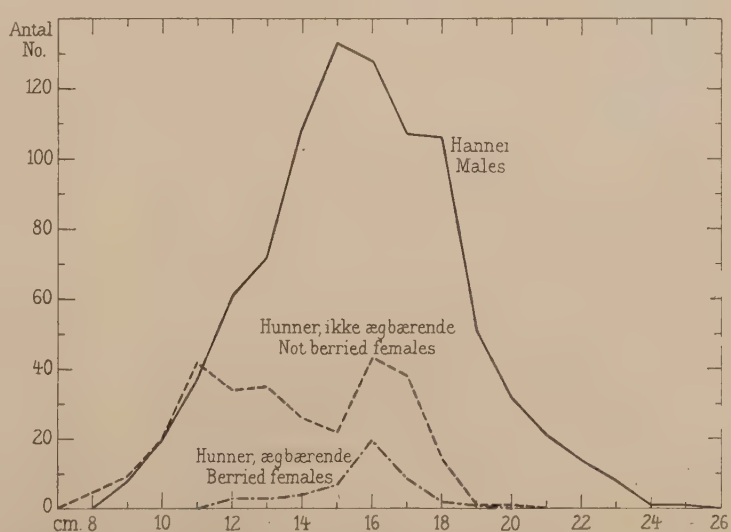

Figure 3. Lengths of males and females (not berried and berried) of Norway lobster, caught in the Skagerak and the northern Kattegat during commercial fishery and scientific fishing experiments.

[1]) B. Havinga: Krebse und Weichtiere. Handb. d. Seefischerei Nordeuropas III, 2, 1929.

Heldt, H. & H.: Des Langoustines dans les mers tunisiennes. Stat. Ocean. de Salambo. Nr. 16. 1931.

sorted samples) from the commercial fishery and the scientific fishing experiments. The length of the females ranges between 8 and 20 cm., that of the males between 9 and 25 cm.; both males and females thus attain a length 3 cm. greater than that stated by Havinga. This difference is apparently connected with the fact that the Norway lobster in the Kattegat and the Skagerak lives in colder water than at the coasts of Holland and in the southern North Sea, from which places Havinga's measurements must be supposed to be taken; for it is a well-known fact that individuals of the same species of marine animals grow the bigger, the farther northwards they are found, that is to say at lower temperatures.

The biggest males of the Danish material are 5 cm. longer than the biggest females. An examination of the mean lengths (Tables 1 and 2) gives the following figures for males and females from the eel-seine and the market samples:

	Eel-seine	Market samples
Males	15.2 cm. (420 ind.s)	16.0 cm. (489 ind.s)
Females.....	12.3 „ (149 „)	15.3 „ (190 „)

In the market samples there is a difference in mean length between the two sexes of barely 1 cm. The smallness of this difference is due to the fact that the commercial fishermen principally use very wide-meshed gears that take comparatively few small individuals, which in this case means females. In the analyses of the catches from the fine-meshed eel-seine the difference in mean length between the two sexes is much greater, the males being 3 cm. longer than the females. In weight this difference becomes rather considerable, Norway lobsters of only 12 cm. weighing about 30 g. apice, individuals of 16 cm. in length weighing about 80—90 g.

Length measurings give no information about the growth rate. The graphs have not two or more apices corresponding to two or more year-classes of Norway lobster in the material. It is true that the graph for females in Figure 3 has two apices, but there is a difference of 5 cm. between them, and this cannot be the growth from one year to the next. According to observations in tanks Norway lobsters of 10—15 cm. will grow by about 0.5 cm. per moulting; like the adult common lobster individuals of this size will probably change their shield only once a year, and so the annual growth cannot by far cover the difference of 5 cm. between the two apices of the graph. These two apices are more likely to represent particularly rich year-classes. The tank observations mentioned above have resulted in a theory that a Norway lobster of 10 cm. is about 7 years old (Hans Höglund)[1]). In other words the growth of the Norway lobster is considerably slower than that of the common lobster, which reaches a length of about 20—25 cm. at an age of 7 years. It is true that the individual measurings (Tables 1 and 2) show some maxima here and there, but they are so inconspicuous, that they cannot be symptomatic of different age groups in the material. The samples measured are no doubt composed of a great number of year-classes, and the difference between the mean lengths of the individual year-classes is so small, that it does not appear in the measuring table.

State of nutrition.

Ratio between length and weight. — Basing on analyses of market samples of Norway lobster (27-IV-35, 18-VI-35 and 28-IX-35) the following table gives the mean weights in grammes of the separate lengths in cm. (the material includes 310 males, 78 not berried and 38 berried females):

	Weight in grammes of		
Length in cm.	Males	Not berried females	Berried females
9	12	16	
10	17	15	20
11	23	22	24
12	31	30	34
13	38	36	35
14	46	44	56
15	57	54	62
16	73	65	73
17	88	83	105
18	107	100	..
19	125	..	..
20	181	..	..
21	197	..	..
22	221	..	..
23	283	..	..

It is seen that on the whole there is little difference in weight between males and females of the same size group: the not berried females are mostly a little lighter, the berried females generally a little heavier than the males.

In Figure 4 we find a graph illustrating the ratio between length and weight. We note that the weight in grammes naturally rises much more rapidly than

[1]) Hans Höglund: De matnyttige kräftdjuren. Fisker och Fiske i Norden, Stockholm, 1942.

the length in cm. When the length is doubled from 10 to 20 cm., the weight rises by about 8 times from about 20 to about 160 g.

The state of nutrition varies somewhat with the sex and the season of the year. In order to get an

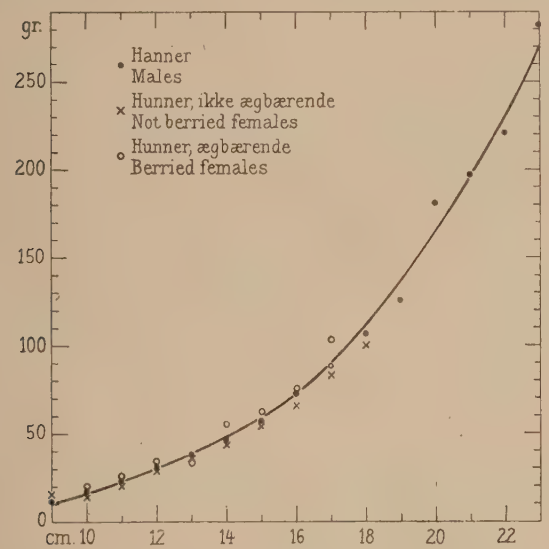

Figure 4. The ratio between length and weight of Norway lobsters (males, not berried females and berried females); the plotting of the curve was based on both males and females. Measurings and weighings originate from the samples from 27-IV-35, 18-VI-35 and 28-XI-35.

expression for the state of nutrition a calculation has been made of the coefficient of nutrition (k), which is expressed by the ratio between length and weight, being calculated from the formula $k = \frac{100\,g.}{l^3}$, where g is the weight in grammes and l the total length in cm.

Weight and length were determined in the analyses from 27-IV-35, 18-VI-35 and 28-XI-35; the following table contains the coefficients of nutrition found for these analyses (numbers of individuals in brackets):

	27-IV-35	18-VI-35	28-XI-35	Total
Males.....	1.86 (106)	1.92 (130)	2.61 (61)	2.04 (297)
Not berried females	1.73 (26)	1.68 (39)	2.10 (11)	1.77 (76)
Berried females	(0)	1.93 (38)	(0)	1.93 (38)
Total...	1.85 (132)	1.88 (207)	2.55 (72)	1.98 (411)

The coefficient of nutrition for all individuals together is 1.98. Generally speaking the males show a somewhat better state of nutrition than the females, i. e.: within the same length in cm. the males are heavier than the females, the coefficient of nutrition being 2.04 for the males, 1.77 for the not berried and 1.93 for the berried females.

There is a distinct change in the coefficient of nutrition during the year, the coefficient for both males and females being much higher in autumn than in spring. Among the males it rises from 1.86 to 2.61 and among the females from 1.73 to 2.10 between April and November. This means for instance that a male of 15 cm. in spring will weigh 63 g. but 88 g. in autumn (at the same length), the corresponding weights of a female of 15 cm. being 59 and 71 g.

Lobsters that have recently changed their shield and are caught during the short period in which the increase of length takes place immediately after must of course weigh less in comparison with the length than individuals taken before or a longer time after the moulting. It might therefore be supposed that the difference in the state of nutrition between spring and autumn is due to a difference in the percental number of individuals taken immediately after the moulting. However, the number of such individuals (with soft shields) is very small in samples from both spring and autumn (2 in the spring samples and 1 in the autumn sample), and so the difference of

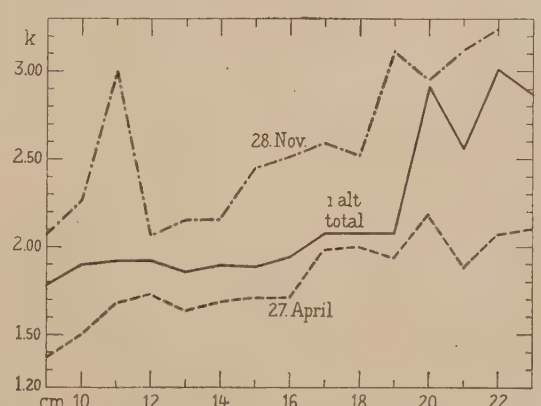

Figure 5. Coefficient of nutrition at different individual lengths of males of Norway lobster, partly for all males of the three samples (total), partly for the analyses of 27-IV and 28-XI separately.

weight is hardly conditioned by this fact. In other words it is very likely that the found difference in the coefficient of nutrition is actually expressive of a better state of nutrition in autumn than in spring.

Figure 5 shows the variation of the coefficient of nutrition with the length of the individual. The figure

Table 3. Coefficient of nutrition (k) of Norway Lobster of various length in the samples from 27-IV, 18-VI and 28-XI-1935.

Length of individuals cm			9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
$^{27}/_{4}$	Males	k	1.37	1.50	1.69	1.72	1.63	1.69	1.71	1.71	1.98	2.00	1.94	2.19	1.89	2.07	2.10
		No.	1	1	4	13	13	15	22	11	8	11	7	2	1	1	2
	Females without eggs	k	2.40	..	1.50	1.91	1.71	1.76	1.53	1.57	1.68	..	..	..	..	..	..
		No.	2	..	2	5	2	3	3	7	2	..	..	..	..	..	..
$^{18}/_{6}$	Males	k	1.92	1.88	1.88	1.88	1.90	1.94	1.93	1.94	1.87	1.68	1.77	2.63	2.38	..	..
		No.	3	6	2	13	19	37	18	16	9	3	2	1	1	..	..
	Females without eggs	k	2.06	1.51	1.59	1.83	1.50	1.94	1.92	1.74	1.63	..	..	..	..	..	..
		No.	1	15	3	3	2	3	6	4	2	..	..	..	..	..	..
	Berried Females	k	..	1.90	1.83	2.27	1.60	2.05	1.83	1.79	2.14	..	..	..	..	..	..
		No.	..	1	3	4	2	11	10	6	1	..	..	..	..	..	..
$^{28}/_{11}$	Males	k	..	2.06	2.25	3.00	2.07	2.16	2.16	2.46	2.51	2.60	2.52	3.12	2.96	3.13	3.25
		No.	..	3	3	1	4	4	8	4	7	3	4	9	2	5	4
	Females without eggs	k	..	..	2.00	..	1.89	2.05	2.13	2.53	2.30	2.44	..	..	..	..	..
		No.	..	..	1	..	2	1	2	2	2	1	..	..	..	..	..

gives the coefficient for the males only, because the number of females in the samples is too small to give a very perfect image of the variation within the different lengths in cm. However, the females are included in Table 3, which also gives the numerical material for the males.

It appears from the figure that the coefficient of nutrition is much higher in autumn than in spring, which was already mentioned above, but besides this the difference is found not only in the stock as a whole but also within each size group; both the small and the big individuals are in a better state of nutrition in autumn than in spring. It further appears from the graphs that the coefficient of nutrition is higher in the big than in the small individuals. For all males the coefficient of nutrition varies between 1.78 and 2.85 at a difference in individual length between 9 and 23 cm. This alone does not necessarily mean that the nutrition of the bigger individuals is so much better than that of the smaller ones; it is also possible that the difference in the size of the coefficient of nutrition is partially due to the fact that the bigger (and older) individuals have a stronger and thicker and therefore heavier armour (shield) than the smaller and younger ones.

Reproduction.

During the copulation the sperm of the male is deposited as a gelatinous mass in a cavity in the sternal plate of the female (the so-called *receptaculum seminis*). In depositing the sperm the male uses the first pair of pleopods, which are modified so that when put together they form a tube, through which the sperm is carried from the sexual opening in the base of the 5th pair of pereiopods to the receptacle of the female. The laying of the eggs takes place some time later; the female then lies down on her back, and the eggs (between about 1.000 and 5.000) pass from the sexual opening at the base of the 3rd pair of pereiopods over the receptacle, where the fertilization takes place, and to the lower side of the hind part of the body (the tail), where they are fixed to the pleopods by means of a glandular secretion.

In the present Danish material females with eggs fixed to the pleopods are found within the size groups 12—19 cm. The percental amounts of berried females within each length in cm. of the total number of females are as follows:

cm.	Total no. of females	Per cent. of them berried
8—11	76	0
12	37	8
13	38	8
14	30	13
15	29	24
16	63	32
17	47	19
18	16	13
19—20	3	33

In other words only a minority of the females of 12—13 cm. are berried; between 15 and 20 cm. the percentage of berried females is 20—30.

According to Swedish investigations (H. Höglund, l. c.) berried females are found down to a length of 10 cm., and in more southerly waters females of only 8 cm. have been found to be berried.

The recently deposited eggs are greenish to greenish black, but when the time of hatching approaches they are more reddish. On the time of laying and hatching H. Höglund writes, "The laying and hatching of eggs are not, as in the case of the lobster, confined to one short period in summer but take place more uniformly during the greater part of the year.—The eggs are carried under the tail of the female for 8—9 months before they are hatched".

The following table gives the information that can be derived from the Danish material concerning laying and hatching:

Time	Total no. of females	Per cent. of them berried	Colour of the eggs
April	26	0	
June-Aug.	226	18	greenish - greenish black
Nov.-Dec.	87	23	greenish blue - greenish black

The material shows that the laying of eggs takes place in late spring and (or) during the summer and that the hatching occurs in early spring, the female thus carrying the eggs under her tail for nearly $^3/_4$ of a year.

According to the statements of the literature the Norway lobster spawns every second year only; the fact that the percentage of berried females in the Danish material is only small and does not reach values above 50 in any of the samples points in the same direction.

In most of the analyses the percentage of berried females is even very low—far below 50, and in certain analyses from the time of the year at which berried females occur not one of them was observed. The explanation is no doubt that the berried females lead a more concealed life and do not come out of their holes so often as the not berried females and the males.

On the whole the females are rather sparse in the catches as will be seen from the following table:

	Males	Females	Total	Percentage of females
Analyses of market samples	489	190	679	**28**
Analyses of eel-seine samples	420	149	569	**26**

So we see that the females make up only about $^1/_4$ of all Norway lobsters taken. The low percentage of females in the market samples may be supposed to be due to the fact that the wide-meshed gears used in this fishery will principally take the big individuals, i. e. the males. But the percentage of females is just as low in the catches from the fine-meshed eel-seine where the mesh-width (the distance between the knots) is only 15—18 mm., and so this can hardly be the cause. The explanation of the low percentage of females is no doubt that the females (also the not berried ones) lead a much more concealed life than the males, so that fewer of them are taken in the catching gears.

On a superficial look the recently hatched Norway lobster is much like a small prawn, but it is easily distinguished from the latter by several long vertical thorns at the upper side of the tail. The build of the young, or the larva as it is called, is very unlike that of the adult individual; its habits of life, too, are quite different because it lives pelagically. In early spring and during the summer the pelagic youngs are often taken in the ring trawl or other gears used for catching pelagic animals (fish larvae). In the course of 3 moultings, more particularly at the third one the look of the larva changes, and after the third moulting, when the young is a little more than 1 cm. long, it is much like the grown-up individual. At the third moulting also the habits of life will change; the older youngs are not taken in the ring-trawl or similar gears used in the open water, and there can be no doubt that this is because the youngs have now taken to the bottom like the youngs of its close relation the common lobster. The three larval stages of the latter last 2 or 3 weeks, and most probably the three first larval stages of the Norway lobster will last nearly the same time.

Larval (pelagic) stages of Norway lobster were taken in the ring-trawl in Danish waters in April, July and October; this means that the hatching takes place at any rate from March till October, a very long period of time, and at very different temperatures, which is of great interest in a biological respect.

The temperature of the sea-water at the depths at which the larvae were taken (about 20—30 m.) appears from the following mean temperatures (C°) of the bottom water (28 m.) at the Anholt Knob L.V. (mean figures for the years 1903—26)[1]:

[1]) From the "Nautisk-Meteorologisk Aarbog" for 1932.

March	4°.3
April	4°.3
May	4°.9
June	6°.7
July	9°.7
August	12°.7
September	13°.1
October	12°.1

In other words the pelagic fry is able to sustain very different temperatures from 4° and up to 13°. This is the more remarkable because the larvae of the marine animals are generally found only within very limited periods and temperatures. The fact that this is not true of the Norway lobster may be due to its very wide geographical distribution from the border of the arctic area (Iceland—the north of Norway) and down to the vicinity of the subtropical area (Morocco and the Mediterranean).

The fishery.

Until the end of the twenties the Norway lobster was without economic importance in the Danish fishery. However, it was often taken in seines and trawls at somewhat deeper water and was now and then landed and brought into the market. By and by it turned out that this palatable crustacean could easily be sold partly by retail, partly to the tinning industry, and about 1930 a regular fishery began.

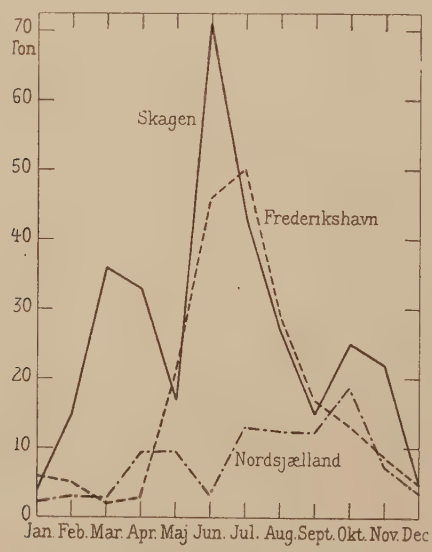

Figure 6. Average landings of Norway lobster in tons for the different months (of the years 1937—39) at Skagen, Frederikshavn and the north coast of Seeland. (From "Fiskeri-Beretningen").

The fact that the large and good factories for the tinning of fish had been established in this country during the previous years was no doubt the principal cause of the rapid rise of the fishery for Norway lobsters. In Sweden a fishery for Norway lobsters had been going on already for a number of years before 1930, and rather considerable quantities had been brought into the market. This fact was apparently a co-operant cause of the start of the fishery in this country.

During the first years, about 1930, the fishery for Norway lobsters was principally pursued in the following localities (according to information received in 1931 from the Fishery Patrol through the Directorate of Fisheries): in the northern Kattegat N. and E. of Læsø and in the area from Læsø through the eastern Kattegat to Skagen in water between 40 and 100 m. depth; in the Skagerak from E. of Skagen to the region off Hanstholm and finally in some few places outside the 40 m. curve of the North Sea. At that time no fishery for Norway lobsters was carried out in the central or southern Kattegat. For the fishery were used trawls or seines.

From 1936 the fishery was also carried out in the central and southern Kattegat where the fishing grounds are found partly in the narrow strip of more than 30 m. deep water from E. of Læsø to E. of Anholt, partly in the 25—40 m. deep area between Anholt, Kullen and Sjællands Odde; finally quite a few Norway lobsters are taken at the northern entrances of the Belts and the Sound. The fisheries in the 3 areas, the Skagerak, the northern Kattegat and the central and southern Kattegat are of fairly the same extent.

For the fishery are mostly used otter-seines (or trawls as the gears are now called in many places). The seine is made of rather thick yarn, and the bag generally has a mesh-width of 52 mm. at the mouth and 34 mm. in the cod-end.

The fishery for Norway lobsters goes on all the year round though the winter fishery is of quite inconsiderable extent. Figure 6 shows the average amounts in tons landed in each month at Skagen, Frederikshavn and the harbours along the north coast of Seeland in the years 1937—39. At all three places the catches are very light, only about 5 tons, in December and January. At Skagen the catches increase rapidly in February, rising to about 35 tons in March and April; they fall somewhat in May but rise to the maximum of 70 tons in June. The yield

decreases rapidly in July, August and September; in October there is another small rise and then another fall to December-January. At Frederikshavn the yield is small also in early spring, and the rise does not begin until May; in June there is an extremely rapid rise, and the maximum, about 50 tons, is reached in July; after this there is a nearly straight fall to a catch of 3—4 tons in December and January. At the north coast of Seeland the catches are small in January, February and March; they rise in April and, apart from a fall in June, remain high throughout the summer and the greater part of the autumn; in November and December there is a rapid fall of the yield. Generally speaking the catches of Norway lobsters are heaviest in summer, somewhat lighter in spring and autumn and quite inconsiderable in winter.

Swedish fishermen also take considerable quantities of Norway lobsters in the Skagerak and the Kattegat; the Swedish catches are almost of the same size as the Danish, and the seasonal distribution of the yield is nearly identical with good catches in spring, summer and autumn and quite inconsiderable catches in winter.

Table 4. Catch in kgs. of Norway Lobster landed in Danish harbours. (From Fiskeri-Beretning).

Year	Skagerak	Kattegat	Belt Sea	Total		Øre/1 kg.
				kg	Kr.	
1931	ca. 10 000		..	10 000	4 000	40
1932	55 000		..	55 000	23 650	43
1933	100 000		..	100 000	25 000	25
1934	280 000		..	280 000	84 000	30
1935	400 000		..	400 000	144 000	36
1936	640 000[1]		..	640 000	280 000	57
1937	124 000	386 000[2]	..	510 000	262 000	51
1938	313 000	358 000[2]	..	674 000	354 000	53
1939	343 000	461 000[2]	..	804 000	405 000	50
1940	62 000		..	62 000	67 000	108
1941	9 393	39 904	75	49 372	93 299	189
1942	106 386		357	106 386	?	?
1943	297 000		..	300 000	695 000	2.30

[1]) Of these 200 000 kgs, were caught in the southern Kattegat and the northernmost part of the Belt Sea.

[2]) Of these a small part was caught in the northernmost part of the Belt Sea.

We do not yet know sufficiently about the biology of the Norway lobster to say precisely why the catches are so small in the winter months. According to Swedish investigations (Höglund, 1942) the Norway lobster seems to live at somewhat shallower water in winter (about 65 m.) than in summer (100—200 m.), and so there is a possibility that in winter it is found in localities that are less approachable (stones) to the seine fishers, but lives at deeper water with the "pure", soft bottom in summer. But we cannot discount another possibility: that the Norway lobster during the cold season—like for instance the plaice—"presses" deeper into the bottom, so that it is difficult to catch it in the comparatively light trawls used for this fishery. Furthermore, the climate throughout the winter—stormy weather and short, dark days—may hamper the fishery considerably. Finally the monthly variation of the catch will depend on the call for the animal, which may vary from month to month.

The Danish fishery for Norway lobsters began about 1930, and the yield of it rose very rapidly in the following years (Table 4 and Figure 7). In 1931, however, it was still so inconsiderable, that it was not reported in the statistics of the "Fiskeri-Beretning" edited by the Directorate of Fisheries. In 1931 the yield was 10.000 kg., but already in the next year it had risen to 55.000 kg. In all the following years there was a steady and constant rise of the yield, which in 1936 reached 640 tons. In 1937 there was

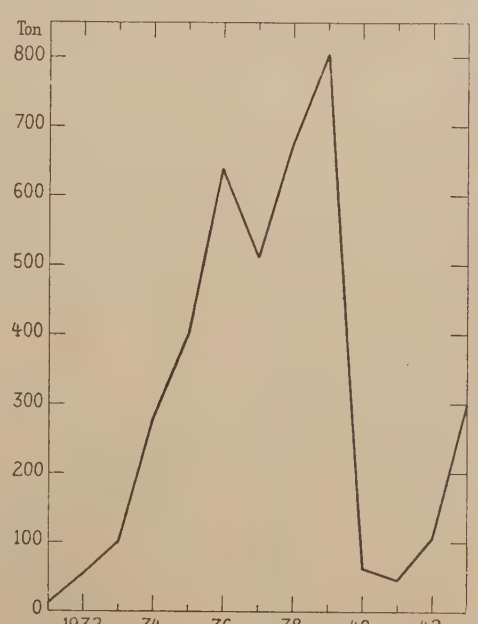

Figure 7. The yield of the Danish fishery for Norway lobsters in the years 1931—43 (from "Fiskeri-Beretningen".

a slight fall, but another rise in 1938 and 1939 brought the yield up to 800 tons. But in the following year there was an extremely rapid decline of this fishery: in 1940 the yield was only 62 tons, and in 1941 there was a further fall to 49 tons; then it rose in 1942 to 100 and in 1943 to 300 tons.

Also in Sweden the fishery for Norway lobsters fell away in the years 1940—42 though the fall was not so great as in this country. The annual catches in Sweden[1]) were about 400 tons in the years 1935—39; in 1940 they went down to 242 tons and rose to 335 tons in 1941. Also in 1942 the catches were small in Sweden: in this year only 100 tons were landed at Gothenburg against about 300 tons in the good years.

It cannot be decided with certainty what was the cause of the great fall of the yields in the years 1940—42. It may be due to the unfavourable fishing conditions caused by the war situation (lack of oil—prohibition of fishery in certain areas). Among the areas that were closed to the seiners were part of the northern Kattegat E. of Skagen-Frederikshavn and the adjacent part of the Skagerak, i. e. the very waters in which some of the most important catching grounds of the Norway lobster are situated. However, it is hardly probable that the whole of the great decrease was due to the conditions of war. On the contrary: to our fisheries as a whole the war situation brought about a considerable rise of the yield, not only of course in value, but also in weight.

A look at the graph representing the yield of the fishery for Norway lobsters (Figure 7) will show that the great fall came about very suddenly in 1940 when the yield fell from 800 tons in 1939 to only 60 tons in 1940; this extremely rapid fall can hardly be put down to the war conditions alone, which in 1940 had not yet made themselves felt to the same extent as in the later years of war. There is some reason to believe that the very cold ice winter at the beginning of 1940 was injurious to the stock of Norway lobster. The following figures represent the temperatures of the bottom water (28 m.) at the Anholt Knob L.V. in April of the years 1935—43 (from "Nautisk-Meteorologisk Aarbog"). From the proper winter months we have no measurings of temperature during the ice winters because the light-vessels were withdrawn on account of ice:

Anholt Knob 28 m., April	
1935	5°.2
1936	5°.6
1937	5°.1
1938	5°.7
1939	5°.0
1940	2°.4
1941	4°.9
1942	ca. 4°.0[1])
1943	5°.3

It appears from these figures that in the very year 1940 even the bottom water temperature was extremely low in Danish waters (only 2°.4 C. against a normal of 5°.5). The rapid decrease in the yield of the fishery for Norway lobsters in Denmark and Sweden coincides with the occurrence of the very low temperatures of the bottom water, and so there is a reason for the belief that the low bottom temperature is co-operant in the decrease of the yield, so that the latter is not merely due to the conditions of war but also represents a direct decrease of the stock caused by the damaging effects of the cold. For the rest it is a well-known fact that our marine animals suffer very much during the cold ice winters.

The Norway lobster has a very slow growth; according to Swedish investigations (H. Höglund, 1942) a Norway lobster of 10 cm., as mentioned above, is already about 7 years old, and it is therefore to be feared that a number of years will pass before the stock recovers after the severe winters. On the other hand the partial protection of the stock, brought about by the conditions of war, may have contributed towards a more rapid recovery than under normal circumstances.

The fishery for Norway lobsters is pursued over a great area from the North Atlantic down to the Mediterranean; the heaviest catches are landed in Denmark, Sweden, England and Germany where they amounted to the following numbers of tons in 1937:

	Denmark	Sweden	England	Germany
Tons	510	475	153	124

The problem of protection.

The Danish Fisheries Act fixes a minimum size of 160 mm. for Norway lobster, measured from the point of the rostrum to the hindmost solid edge of the

[1]) Sveriges officiella Statistik. Fiske.

[1]) The light-vessel withdrawn on account of ice in the first half of the month.

telson[1]). A look at Figure 3 will show that the majority of the females and nearly half the berried females taken in the gear are protected by this minimum size-limit[2]), so that the catches principally consist of the males, which grow bigger than the females. The fact that so great a part of the berried females are below the minimum size may naturally lead to the assumption that the renewal of the stock is fairly safe on account of the existing minimum size-limit, but things are not so simple as that. Two facts must be remembered in this connexion: firstly the males are necessary for the reproduction, and in a case like this where a direct copulation takes place, they must be present in nearly the same number as the females; secondly the fishery often takes place in so deep water and the animals will suffer so much from being hauled out that they are incapable of surviving when liberated again.

The question of protection should undoubtedly be subjected to a renewed examination in collaboration with the other countries fishing for Norway lobsters in the waters round Denmark.

The Deep-Sea Prawn.

Introduction.

The deep-sea prawn (*Pandalus borealis*) is a remote relation of our common prawn and grows nearly twice as big as the latter. Like a number of other deep-water crustaceans it is red; when cooked it keeps its red colour, which only grows a little lighter, but at the same time the translucency of the living prawn disappears. In the same places as the deep-sea prawn we find one or two other species of red prawns, but the former is distinguished from the others principally by its long rostrum, which shows a slight upward bend.

The habitat of the deep-sea prawn is the somewhat deeper areas of the arctic and semi-arctic seas. It is found over a very vast area both on the eastern and the western hemisphere: off the coasts of Greenland and northern Europe, in the sea between northern Asia and North America and off the northeastern coast of North America. At the coasts of Europe the southern limit of its occurrence is found in the North Sea off northern England and in the Kattegat.

The depths at which it is found range between about 50 and about 1.000 m., the depths most frequently inhabited lying between about 150 and 400 m.

Since the beginning of the present century deep-sea prawns have been fished for at the Skagerak coasts of Norway and Sweden; the Danish fishermen began to fish deep-sea prawn in the Skagerak in 1931.

[1]) In Sweden the corresponding minimum size is 150 mm.

[2]) Under the condition that they are fit to survive when liberated again.

Occurrence.

In Danish seas the deep-sea prawn lives in the northern part of the North Sea, in the Skagerak and in the northern and eastern Kattegat (see Figure 8). Adult deep-sea prawns were found as far southwards in the Kattegat as halfway between Anholt and Gilleleje, but the youngs advance even further southwards: a young individual of 47 mm. was taken in the Sound S. of Hven at 28 m. depth on 7-X-28. However, large amounts of deep-sea prawns are found only in the Skagerak and in the adjacent, northeasternmost part of the Kattegat.

During the investigations made by the Danish Biological Station deep-sea prawns were found at depths between 60 and 650 m. The following table shows in how many hauls with bottom-trailing gears (otter-seine and eel-seine) inside these depths adult deep-sea prawns were taken during the years of Danish investigations:

Depht in m.	Total no.s of hauls	No.s of hauls with deep-sea prawns	Percental no. of hauls with deep-sea prawns
60—100	11	6	55
101—150	13	10	70
151—200	8	8	100
201—400	17	17	100
401—600	9	3	33
ab. 600	6	1	17

As will be seen from these data the most frequent occurrence of the deep-sea prawn falls between depths of 150 and 400 m. where it was taken in all hauls;

Figure 8. The distribution of the deep-sea prawn in the waters round Denmark. ● denotes places where adult deep-sea prawns and ○ places outside the proper area of occurrence where youngs were caught during the scientific fishing experiments from the "Thor", "Dana" and "Biologen" in the years 1903—39. ÷ denotes an area in the deepest Skagerak, inside which no deep-sea prawns were observed.

between 60 and 100 m. it was found in just above half the hauls. At greater depths than 400 m. it grows rarer: here it was taken only in nearly $^1/_5$ of the hauls.

The youngs will occur at considerably shallower water than the adult individuals: in several cases youngs were taken inside the 25 m. curve.

In the places where adult deep-sea prawns were taken at the bottom the temperatures of the bottom water were found to range between 5°.1 and 9°.5 C., being in most cases between 5° and 6° C.; the highest temperatures (7°—9°.5) were found at depths inside 200 m. but still in localities where comparatively large amounts of deep-sea prawns were taken: a considerable part of the Danish fishery for deep-sea prawns takes place in summer at depths between about 180 and 200 m. and at a bottom water temperature of 7—8°, which shows us that this temperature is not too high for the deep-sea prawn.

At the same stations at which the said temperatures were found the salinity of the bottom water was found to range between 34.1 and 35.7 $^0/_{00}$. The deep-sea prawn must be regarded as distinctly confined to water of a high salinity; it is a decidedly stenohaline animal, i. e. it suffers only a very slight fall of salinity.

As already mentioned the fry, i. e. the youngs leading a more pelagic life, spread over a vaster area than the adult prawns. Correspondingly, they do not seem to be so sensible to variations of temperature and salinity: young deep-sea prawns (schizopod-stages) were found in the southern Kattegat at a salinity of only 32 $^0/_{00}$ and a temperature of 13—14° C.

Growth and reproduction.

During the last decennium the biology of the deep-sea prawn has been thoroughly examined in Scandi-

navian waters[1]). The principal result of these investigations was the demonstration of the fact that the deep-sea prawn, like a few other decapod crustaceans, changes its sex during its development: when it grows mature for the first time, in its second year of life, it is a male, but then the sex changes and in the next period of reproduction, in its third year of life, it has developed into a female. If it lives for another year or more, it remains a female.

The eggs are spawned in late summer and autumn and are deposited under the abdomen of the female, which carries the eggs for nearly six months. The hatching takes place in spring. According to the investigations of Hjort & Ruud the recently hatched youngs live pelagically for about 3 months, during which time they moult several times. In late summer the youngs at a length of about 2 cm. take to the bottom, and for the rest of its life the deep-sea prawn remains decidedly a bottom animal.

According to Hjort & Ruud the 1 year-old prawns are about 8 cm. long; when 2 and 3 years old they are about 10.5 and 12.5 cm., respectively (total length). During the following years their growth is insignificant: the biggest deep-sea prawns found in Scandinavian waters were about 16 cm. long.

The development from male into female takes place during the winter and the early spring at an age of barely 2 years and a length of about 10 cm.; generally speaking we may say that deep-sea prawns of less than 10 cm. are males while those above 10 cm. are females.

The Danish investigations in the Skagerak, carried out mainly in the years 1935—38, correspond very well with the results of the Norwegian and Swedish investigations.

In spring, in April, we find females carrying their eggs under their tail, but later on, in July and August, we find no such females, and so the hatching of the eggs must have taken place during the intermediate time. In July, August and September the ovaries are often seen to be full of eggs, but individuals with eggs under their tails are not yet found. In other words the spawning takes place at a later point of time, i. e. a little later in autumn.

During the fishing experiments with the eel-seine carried out by the Biological Station in the years 1934—38 a number of hauls were made within the area of the Skagerak in which Danish fishermen fish for prawns, i. e. NE., N. and NW. of Skagen at a depth of about 200 m. Part of the material taken in the eel-seine was measured. The individuals were measured in mm.; in some cases the total length was measured, i. e. the length from the point of the rostrum to the edge of the telson; however, the long, thin rostrum is often broken after the capture, so that part of it is lacking, and therefore this measuring method is in some cases uncertain because it may be difficult to see that the rostrum has been broken,

Table 5. Measurements of length (from the anterior edge of the eyes to the point of the telson) of Deap Sea Prawn caught in the Skagerak with the "Eeltog" from S/S "Biologen" and with the prawn trawl during commercial fishery.

	13 M. N. b. E. of Skagens Rev. L. V. 207 m. 13. 7. 1934 Eeltog	28 M. N. b. W. 3/4 W. of Skagen L. 227 m. 19. 8. 1935 Eeltog	26 M. N. b. W. of Skagen L. 198 m. 7. 7. 1936 Eeltog	25 M. N. b. W. 1/2 W. of Skagens Rev F. S. 210 m. 27. 8. 1937 Eeltog	23 M. N. 1/2 E. of Skagen 203 m 23. 8. 1938 Eeltog			Eeltog, Total	14 M. N. b. E. of Skagen ca. 200 m. 13. 7. 1934 prawntrawl
					♂	♀	?		
cm									
4.5	..	1	..	..	..	..	..	1	..
5	7	1	..	..	..	..	1	9	..
5.5	4	3	..	1	..	..	3	8	..
6	7	14	5	3	3	..	12	35	..
6.5	52	25	35	26	12	..	53	162	..
7	77	68	86	57	35	..	27	376	..
7.5	30	47	40	36	15	..	6	195	2
8	3	22	10	5	11	2	2	59	6
8.5	7	8	13	3	6	6	10	45	14
9	7	21	15	5	..	12	3	70	16
9.5	6	10	13	7	..	11	..	50	27
10	4	6	10	4	..	6	..	30	19
10.5	2	2	..	4	..	1	1	10	10
11	2	..	1	..	..	..	..	3	2
11.5	..	..	..	..	..	..	..	..	1
12	..	..	..	..	..	..	..	..	1
Total	208	228	228	151	82	38	118	1053	98

[1]) F. Leopoldseder: Geschlechtsverhältnisse und Heterochromosomen bei *Pandalus borealis* Krøyer. Zeitschr. wiss. Zool. 145. 1934.

G. Jägersten: Über die Geschlechtsverhältnisse und das Wachstum bei Pandalus. Ark. f. Zoologie. B. 28 A. No. 20. 1936.

Joh. Hjort and Joh. T. Ruud: Deep-sea prawn fisheries and their problems. Hvalrådets Skr. Det norske Videnskap. Akad. Nr. 17. 1938.

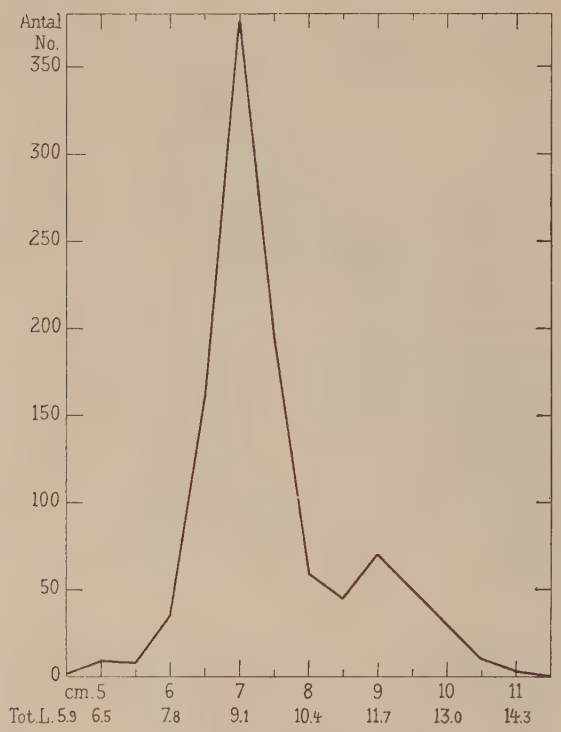

Figure 9. Lengths of deep-sea prawns from the front of the eyes to the edge of the telson; the figures at the bottom represent the corresponding total lengths. The material originates from the eel-seine fishery N. of Skagen, about 220 m., in 1934—38 (July—August).

especially when this has happened comparatively near to the point. In order to avoid this possible error we have in most cases also, or exclusively, measured the length from the front of the eyes to the outer edge of the telson. The total length is found by multiplying this measurement by 1.3.

Figure 9 is a graphical representation of the result of all measurings (Table 5). The measurements range between 4.5 and 11.5 cm. (corresponding to total lengths of 5.9—15.0 cm.) In the graph there is a very pronounced maximum at 7 cm. (total length 9.1) and another very indistinct maximum at 9.0 (total length 12.0 cm); the former (higher) maximum corresponds to the $1^1/_3$ year-old individuals (I-Gr.), which act as males, the latter to the $2^1/_3$ year-old individuals (II-Gr.), which act as females. The decrease in the number of individuals from the I-Gr. to the II-Gr. is so great, that it can hardly be due to the natural mortality alone; it must be put down to the influence of the fishery as well because the latter principally removes individuals of more than 9 cm. in total length. One of the graphs of Figure 10 represents the measurements of a sample of deep-sea prawns caught by the commercial fishermen in the Skagerak; it appears from the graph that the deep-sea prawns with a total length of 9 cm. and upwards are the very individuals taken by this fishery.

The other graphs of Figure 10 show the lengths from a sample taken with the eel-seine, the individuals of which were divided into males and females. The size of the males ranges between about 8 and 12 cm. with a maximum at 9 cm., that of the females between 10 and 14 cm. with a maximum at 12 cm. In other words these maxima correspond very well with the two maxima of 9 and 12 cm. found in the graph representing the individuals the sex of which was not determined.

A comparison between the 3 graphs of Figure 10 further shows that the size graph for the market sample individuals coincides with the size graph for the females, which means that the commercial fishery principally removes the bigger, female individuals while the males generally speaking avoid being taken by the fishermen.

The lengths found for the different age-groups and sexes during the Danish investigations in the open Skagerak agree very well with those observed during investigations in the skerries of Norway and Sweden: as regards conditions of growth and change of sex the deep-sea prawn of the open Skagerak shows a close correspondence with the stocks of deep-sea prawn living in the sheltered water of the fiords of the Skagerak coasts of Norway and Sweden. This

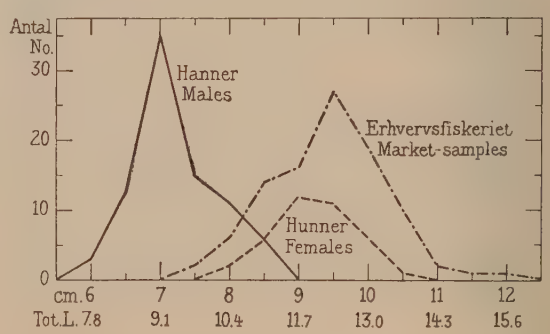

Figure 10. Lengths of males and females of deep-water prawns caught in the eel-seine 23 naut. miles N. of Skagen, at 203 m., on 23-VIII-38, measured from the front of the eyes to the outer edge of the telson; the figures at the bottom represent the corresponding total lengths. For comparison's sake are given the measurements from a market sample taken 20—25 naut. miles NNW. of Skagen on 13-V-34.

biological uniformity of the stocks of these areas may mean that the two stocks live and thrive under fairly the same conditions, but it may also be the consequence of an intense interchange of individuals of the stocks through a transport of larvae with the marine currents. In the question of an introduction of protective regulations it is of considerable interest that the different stocks show such a uniformity of biological conditions.

The fishery.

Nearly half a century ago deep-sea prawns were fished only in one very limited area at Drammen in the Oslo Fjord, and the catches were very light. But already at that time it was known that the deep-sea prawn was living over much vaster areas. The Danish zoologist Henrik Krøyer found the deep-sea prawn at Greenland and described it already in 1838. Later on it was found in the Swedish skerries and other localities of the Skagerak area, but it had not been attempted to catch it in suitable gears (fine-meshed trawls), and so it was unknown that this prawn occurred in large quantities within these areas.

At the end of the nineties C. G. Joh. Petersen, the late director of the Danish Biological Station, managed to construct a fine-meshed trawl that could be used in deeper water by smaller vessels. During a fishery with this gear it was demonstrated that large quantities of deep-sea prawns occurred in the Gullmarfjord at the Skagerak coast of Sweden, and in 1898 Joh. Hjort in using the same gear found that there was a rich stock of deep-sea prawn in several fiords of southern Norway. After this had become known the fishermen of the Norwegian and Swedish skerries began to fish deep-sea prawns with trawls. In Norway the catching grounds were steadily extended westwards and northwards along the coast, and at the same time the yield of the fishery rose. In 1908 it had reached 400 tons, and for a long period of years it remained here apart from lesser fluctuations. But at the beginning of the twenties there came a great rise; about 1930 the yield had reached 1.200 tons and in 1935 nearly 3.400 tons. During the last years before the second great war there was a fall of the yield, which in 1937 and 1938 was nearly 2.900 tons.

The Swedish fishery is considerably smaller than the Norwegian, which is quite natural because the catching grounds, the fiords at the coast of Bohuslän and—during recent years—the open parts of the Skagerak, are of much smaller extent than in Norway where they cover most of the Norwegian coast from the Oslo Fjord up to the area about Tromsø. During the years before the first great war the yield of the Swedish fishery rose to about 180 tons; it remained here till the end of the twenties when it began to rise rapidly, reaching about 1.200 tons in the beginning of the thirties. As in Norway there has been a decrease during recent years: in 1939 the yield was barely 1.000 tons and in 1941 only 700 tons.

In this country the deep-sea prawn fishery began as late as 1931. The fishing grounds were situated first and foremost N. of Skagen at depths of about 150—250 m., less important grounds lying further westwards in the Skagerak and the northeastern North Sea near the 100 and 200 m. curves.

The deep-sea prawns are caught exclusively with the trawl; the head rope of the gear is mostly 70 m., the foot rope 77 m. and the bag about 15 m. long. The mesh-width of the wings of the trawl is 23—28 mm. from knot to knot and 18—20 mm. in the bag.

The fishery takes place at daytime, and the best hauls are made in the middle of the day when the weather is brightest. The small extent of the fishery in winter among other things is due to the fact that the days at this time are so short and dark.

In former days the prawns were cooked onboard the boats immediately after the capture, but now they are generally packed with ice and landed fresh, a cooking taking place only when no ice can be procured. Nearly the whole of the Danish fishery for deep-sea prawns takes place from Skagen where the bulk of the catches is sold to the tinning factories while smaller quantities are sold in an unpreserved state.

The yield of the Danish fishery shows a very rapid rise in the course of years (see Table 6 and Figure 11). In 1931 the yield was only 28 tons; in 1936 it had risen to about 240 tons, in 1941 to 300 and in 1943 to nearly 600 tons. Nearly all the catches originate from the fishing grounds of the open Skagerak NE., N. and NW. of Skagen (150—250 m. depth). During the same years the value of the catches rose from about 25.000 Kr. to about 1.300.000 Kr. In the years before the war the price varied between 79 and 108 Øre per kg., but during the war it rose to 150 Øre or more on account of the abnormal conditions of paying.

The Danish deep-sea prawn fishery is decidedly a

Table 6. Yield in kgs. and Kr. of the Danish Fishery for Deep Sea Prawns, 1931—43.

Year	North Sea	Skagerak	Total kgs.	Total Kr.	Kr./kg.
1931.....	4 200	23 936	28 136	25 121	0.90
1932.....	13 800	41 208	55 008	45 969	0.84
1933.....	40	38 130	38 170	31 575	0.83
1934.....	5 670	161 797	167 467	144 893	0.86
1935.....	3 200	168 711	171 911	140 000	0.83
1936.....	4 125	239 191	243 316	203 268	0.84
1937.....	..	156 764	156 764	158 836	1.01
1938.....	..	221 563	221 563	238 255	1.08
1939.....	..	370 882	370 882	294 235	0.79
1940.....	..	218 642	218 642	247 220	1.13
1941.....	..	293 300	293 300	404 359	1.38
1942.....	..	393 272	393 272	550 000	1.50
1943.....	..	590 000	590 000	1 270 000	2.15

seasonal fishery. Figure 12, which is based on Table 7, shows the mean weights in tons of deep-sea prawns landed at Skagen in the different months of the years 1934—40. In the winter half-year October—March it is below 5 tons a month. During the spring months it rises rapidly reaching its maximum in June and July with about 50—55 tons. Then there is a rapid decrease ending below 5 tons in October. The catches in June–July are so heavy, that nearly half the total catch of the year is taken in these two months alone.

Judging from the few items of information given by Hjort & Ruud (1938) concerning the season of the prawn fishery it seems to be not nearly so much of a seasonal fishery in Norway as in this country, though the catches are a little heavier in the summer than in the winter half-year. Also in Sweden the prawn fishery shows a rather uniform distribution throughout the year, but here, too, the smallest catches are made in winter.

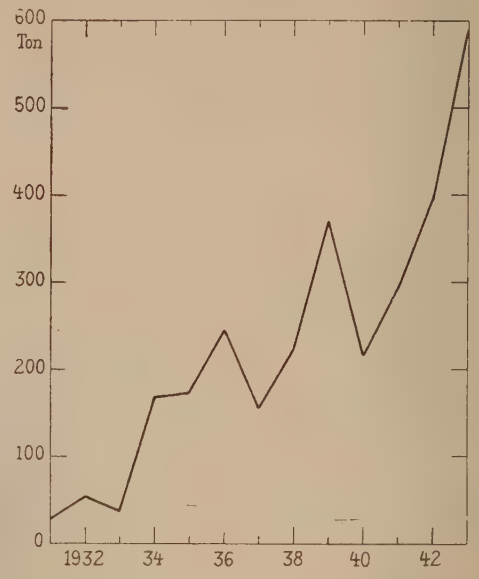

Figure 11. Yield in tons of the Danish deep-sea prawn fishery in the years 1931—43 (from "Fiskeri-Beretningen").

In other words the decidedly seasonal fishery—heavy catches in summer and quite light ones in winter—is a characteristic of the Danish deep-sea prawn fishery.

While the Danish fishery nearly exclusively takes place on the said catching grounds N. of Skagen, Norwegian and Swedish fishermen work a much vaster area of the Skagerak, partly further north-

Table 7. Mean weight in kgs. of Deep Sea Prawns landed in Skagen in the various months of the years 1934—40.

Year	Jan.	Febr.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
1934	..	..	1 090	7 260	21 550	46 290	62 900	18 015	1 970	1 680	2 250	1 065	164 070
1935	145	50	1 760	29 395	37 250	21 440	22 475	39 490	10 240	405	80	..	162 730
1936	..	250	3 715	9 475	58 425	38 454	52 928	38 655	17 255	9 878	..	..	229 035
1937	..	498	6 782	5 294	25 552	4 331	42 709	56 689	12 881	1 521	40	..	156 267
1938	..	3 523	3 678	10 119	39 487	26 509	71 337	36 963	24 126	5 821	..	..	221 563
1939	23	167	918	25 504	76 263	75 923	70 845	62 916	41 438	11 991	4 894	..	370 882
1940	..	92	4 449	5 265	826	148 211	56 725	1 767	1 307	..	..	..	218 642
Middle...	24	654	3 199	13 187	37 050	51 594	54 274	36 356	15 602	4 471	1 039	152	..

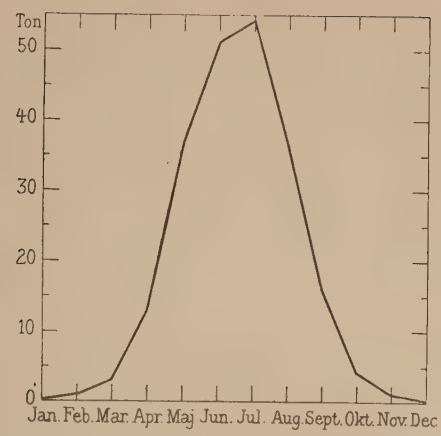

Figure 12. Mean weights in tons of deep-sea prawns landed at Skagen in the different months of the year; mean for the years 1934—40 (from "Fiskeri-Beretningen").

wards along the 200 m. curve up to Svennerbanke SE. of Larvik, partly westwards along the 200 m. curve to the border area between the Skagerak and the North Sea (Hjort & Ruud, 1938). This means that there is a possibility of extending the Danish catching grounds.

The relation of the fishery to other fisheries and the stock of deep-sea prawns.

Speaking about a fishery with fine-meshed gears it is quite natural to ask whether such a fishery will spoil considerable quantities of the fry of utility fishes.

In this country where the fishery takes place far seawards and at great depths there has hardly been any scruples to this effect. Things are different in our neighbouring countries, especially in Norway where the fishery is mostly carried out some way into the fiords, at rather great depths it is true, but still very near to important nursery grounds of the fry of utility fishes. However, careful Norwegian investigations (Hjort & Ruud, 1938) have shown that very small amounts of the fry of utility fishes are spoiled by this fishery. In a number of localities considerable quantities of small whiting are taken in the prawn trawl, but it has nowhere been possible to establish a decrease of the whiting fishery within the period in which the fishery for deep-sea prawns took place. In other words the Norwegian investigations have found nothing to indicate that the deep-sea prawn fishery should injure the stocks of utility fishes.

On the fishing ground N. of Skagen (160—250 m.) where the Danish fishery for deep-sea prawns goes on the Danish Biological Station during recent years made a number of hauls with the eel-seine, which, as regards mesh-width (15—18 mm. from knot to knot), is much like the prawn trawl with its mesh-width of 16—18 mm. In these hauls (13 in all) the catches of fishes and utility crustaceans per 30 minutes were as follows:

Cod	0.5	ind.
Haddock	0.3	-
Coalfish	0.1	—
Whiting	2	-
Poor cod	8	—
Norway pout	8	-
Couch's whiting	44	—
Hake	0.2	—
Rockling (*Onos cimbria*)	52	—
Lycodes vahli	25	—
Lysenchelys sarsi	0.4	—
Silvery pout	7	—
Long rough dab	1	—
Witch	1	—
Norway haddock	0.1	—
Angler	0.1	—
Great silver smelt	3	—
Rabbitfish	5	—
Norway lobster	8	—
Deep-sea prawn	3	kg.

Of our more important utility fishes very few individuals were taken together with the prawns, among them principally the codfishes, of which quite a few were taken per 30 minutes: 0.5 cod, 0.3 haddock, 0.1 coalfish and 2.0 whiting. Of other utility fishes were taken hake (0.2) and pole-dab (1). In other words the quantities were quite insignificant. The lengths of the few utility fishes found in the catches were as follows:

6 cod: 39, 47, 61, 68, 87, 96 cm.
3 haddock: 10, 12, 34 cm.
1 coalfish: 86 cm.
21 whiting: 9–20 cm. – 15 pieces, further 21, 23, 24, 25, 27, 35 cm.
2 hake: 35, 41 cm.
15 witch: 10, 11, 11, 11, 13, 17, 19, 23, 25, 27, 30, 35, 45, 40, 45 cm.

This means that the individuals of this species were mainly bigger fish; of young fish were taken only 2 haddock, 15 whiting and 7 witch. These

amounts of young fish are extremely small and quite insignificant as compared to the quantities ruined by other fisheries (otter-trawl) within and near the areas of the prawn fishery, so that there is no reason whatever to fear that the stock of utility fishes should suffer from the deep-sea prawn fishery.

Besides of Norway lobsters, nearly exclusively of a marketable size, the incidental catches of the prawn fishery consist of a number of smaller species of codfish, mostly Couch's whiting, rockling and *Lycodes*. The incidental catches are sold as waste fish and are used partly as fish fodder in the pond farms, partly for the production of fish meal and other industrial products.

A sample of waste fish taken as incidental catch in the commercial deep-sea prawn fishery 15 naut. miles N. by E. of Skagen on 1-V-44 showed the following composition:

Whiting (*Gadus merlangus*)	11.1 kg.	11-24 cm.	length
Couch's whiting (*Gadus poutassou*)	3.1 -	22-37	—
Rockling (*Onos cimbria*)	2.0 -	10-29	—
Rabbitfish (*Chimæra monstrosa*)..	1.2 -	17-50	—
Witch (*Pleuronectes cynoglossus*) .	1.0 -	15-27	—
Hake (*Merluccius vulgaris*)	0.47-	16-28	—
Lycodes Vahli	0.12-	15-18	—
Poor cod (*Gadus minutus*)	0.10-	10-13	—

Apart from whiting and quite a few witch and hake this sample contains no utility fishes or youngs of them.

Another problem is whether the stock of deep-sea prawn itself is able to bear the fishery. In the Norwegian and Swedish skerries where the deep-sea prawn fishery has been going on for more than 40 years it has been experienced in many localities that the stock has greatly decreased. Hjort & Ruud (1938) say that the daily catches in 1905—06 were about 44 kg. against only 8—13 kg. in the years up to 1938, from which they draw the conclusion that the stock was 4 or 5 times larger in 1905—06 than in the thirties. The authors think that this great decrease of the stock is not so much due to the removal of the bigger, marketable individuals as to the quantity of young deep-sea prawns that are retained by the trawl and are unable to survive if liberated again. The bigger individuals among these youngs are often landed and sold at comparatively low prices to the tinning factories. Through a series of experiments the two authors arrived at the result that a trawl with a mesh-width (measured in wet state) from knot to knot of 14 mm. will spare a considerable part of the youngs (individuals below 10 cm. total length, i. e. the majority of the individuals at the male stage and younger individuals) without fishing smaller quantities of the big prawns. In Norway the bags generally used at present have a mesh-width of 12—16 mm. from knot to knot.

In the prawn trawl used by Danish fishermen the mesh-width of the bag is 16 mm.; though this is a measurement of a dry trawl, it is evident that the mesh-width of the Danish trawl is at any rate not less than the 14 mm. from knot to knot recommended by Hjort & Ruud. The Danish fishermen state that nearly $^1/_{10}$ of their catches are small prawns of no market value.

Hjort & Ruud say that in summer nearly $^1/_3$ of the catch in a trawl with a mesh-width of 14 mm. consists of small prawns (less than 10 cm. in total length). This figure is rather high, and possibly it will therefore be necessary to introduce a somewhat greater mesh-width even if this will result in a lower weight yield per haul of big prawns. But in this connexion it must be remembered that a lower weight yield at any rate to some extent wlil be compensated for economically by the fact that also the mean size of the bigger prawns alone—and hence the value in Kr./kg. — will rise with a greater mesh-width. At any rate a greater mesh-width will mean a better protection of the stock of prawns and, consequently, a higher yield of the fishery throughout the years.

However, a protection of the stock can also be obtained by the introduction of a close season, during which the deep-sea prawn fishery is prohibited. The market value of the prawns to some extent depends on the moulting because prawns that have moulted a short time ago and therefore are softer are less preservable and resistant than others that have a harder and more solid shield. If a close season is introduced, it will be advisable to place it at a time of the year when moultings are particularly frequent and the amount of prawns with soft shields is therefore comparatively great. The somewhat bigger prawns changing their sex from male into female at an age of about two years have their period of most rapid growth and most frequent moultings in January and February (Hjort & Ruud). At the end of the third year of life when the eggs under the tail of the female have been hatched there is another period of rapid growth and comparatively many moultings in

March and April. During the time between January and April we thus have a period with comparatively many moultings, and so it will be desirable to place the close season within this period, more particularly because the females at this time are carrying the mature roe. How great a part of this period should be covered by the protection must of course be decided from the degree of protection that is found necessary and with due regard to the work of the fishery.

During the period of little more than 10 years, in which Danish fishermen have been fishing deep-sea prawns N. of Skagen no decrease has been observed in the stock of deep-sea prawns or in the size of the individuals, and this is no wonder considering the shortness of the period and the rather limited extent of the fishery during the first years.

In view of the continued thriving of the stock, however, it would be desirable to introduce the regulations of protection at a time when the stock has not yet suffered particularly from the effects of the fishery.

The deep-sea prawns of the open Skagerak are caught within the international territory, and not only Danish but also Norwegian and Swedish fishermen take part in the fishery; also fishermen of other countries will possibly turn up in future in order to get a share in the yields. A protection of the deep-sea prawn should therefore be enacted internationally and be obligatory for fishermen of all countries. As soon as possible after the end of the second great war it will therefore be desirable to try to introduce international regulations for the protection of the deep-sea prawn.

Extensive Mortality in Trout Caused by the Infusorian *Stentor polymorphus* Ehrenb.

By

C. V. OTTERSTRØM and KNUD LARSEN

For some years on end Mr. Johs. Errboe, a trout pond farmer at Lysbro near Silkeborg had a remarkable experience in depleting a small pond of his. The pond was used for the breeding of fingerlings of brook trout and year by year turned out to be well suited for the purpose inasmuch as the fish thrived excellently. When the emptying took place, however, it happened every year that the first part of it passed without mishap, but when the level of the water had sunk rather low, the fish that remained in the pond grew restless and died after having darted about the pond for a short while.

This recurred so regularly year by year, that Mr. Errboe at last asked the Biological Station to attend the depletion and possibly to find out why the fish died. For this reason one of the authors (C.V.O.) came to Lysbro on 27th August 1943. The pond had then been drained of some of its water, and many of the fingerlings had left the pond and were standing in sorting boxes in the Lysbro Brook; they were all alive. Owing to the inspection the draining had been interrupted, and in the shallow water of the pond many trout were seen to be dead, but among them others were swimming, apparently being none the worse and showing no signs of restlessness.

The pond (Figure 1) is nearly triangular and receives its main affluent (a) at one side; there is another small affluent (b) at the acute angle of the triangle. The outlet (c) is found at the opposite side. The dead fish were mostly lying between (a) and (b); their opercles were distended as if they had been suffocated. The affluent (a) comes from another pond where nothing has ever been the matter. The affluent (b) is spring-water from the slopes of the hills. The spring-water had a pH of about 6.6; the pH of the pond-water showed the same value and had a hardness of $2^1/_2$ German degrees.—There was some vegetation in the pond, mostly water-weed (*Elodea*) but also some starworts (*Callitriche*) and green confervae. The vegetation was full of loose, greyish-brown mud. There were many snails in the pond, no doubt exclusively *Limnaea ovata*, but there were hardly more of them than in other ponds.

One or two handfuls of *Elodea* were stirred in a pail of pure water from affluent (a), and 6—8 of the fresh fingerlings from the sorting box were put into the water dirtied in this way. After a couple of minutes the fish grew restless, and after 5 minutes

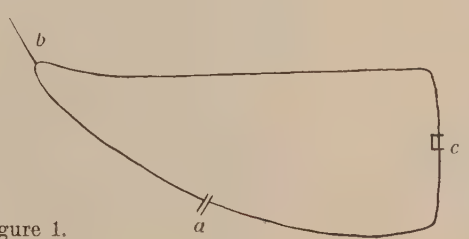

Figure 1.

some of them were lying upside down while others, as in spasms, shot to the surface gasping and vomiting irregularly, much like fish exposed to flagellate poisoning[1]). About 10 minutes after they had been put into the pail all the fish were lying upside down. When transferred to pure water only two of them showed occasional movements of the gills, and a short time later all of them had died.

A milk-pail of water dirtied in the same way by stirring of vegetation was sent to the laboratory at Frederiksdal. On account of the state of emergency it did not arrive until 3rd September and on the arrival the water had a rotten smell, for which reason it was poured into a tub and aired.

[1]) C. V. Otterstrøm and E. Steemann Nielsen: Two cases of extensive mortality in fish caused by the flagellate *Prymnesium parvum*, Carter. Rep. Dan. Biol. Stat., XLIV, 1939.

The water contained many individuals of the about 1 mm. long infusorian *Stentor polymorphus* Ehrenb. (Figure 2), which were greenish on account of their symbionts of green algae of the collective species *Stentor* alga), but several other green algae also occurred, *i. a.* an *Ankistrodesmus* species, whereas the small rod-shaped *Cyanophycea* was not found here.

For the determination of the *Stentor* species and

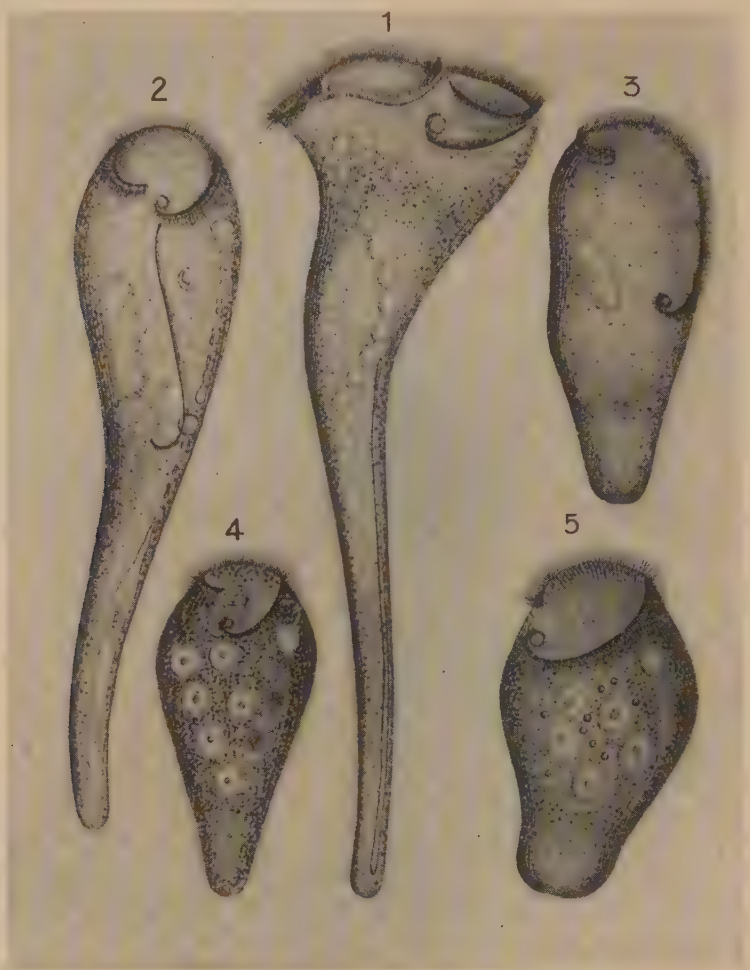

Fig. 2. *Stentor polymorphus* Ehrenb. — The small balls scattered all over the animal are green algae (*Chlorella vulgaris* Beijer). The animal is pictured in a extended state (1), somewhat rounded, beginning to divide (2), with little *Chlorella* (3) and in its swimming shape (4—5). From Friedrich Stein.

Chlorella vulgaris Beijer. Besides them many small rod-shaped algae (no doubt *Cyanophyceae*) were found lying in round lumps; they could not be determined. When the water with the Stentors was left quietly, the animals settled on parts of plants and the like, but could easily be shaken off again. In the culture made of the symbionts of *Stentor Chlorella* was particularly frequent (probably identical with the

for the pure cultivation of it and its symbionts we are indebted to Mag. scient. Nils Andrésen and for the determination of the algae to Dr. phil. J. Boye Petersen.

A number of experiments were now made with the water from the Lysbro pond; the fish used for the experiments were young rudd at a length of 2.5—3 cm.

Experiment A. 3-IX-43.

3 glasses { I. with unfiltered water from the Lysbro pond
II. — filtered — — - — —
III. — water from the lake Furesø.

At 2.41 p.m. 2 young rudds are put into each glass.
- 2.50 — the fish of glass I are seized with cramps and float about.
- 2.52 — the fish of glass II are seized with cramps and float about.
- 3.03 — the fish of glass I have died.
- 3.04 — the fish of glass II have died.
- 3.04 — the fish of glass III are alive and comfortable.

Experiment B. 3-IX-43.

Into a glass with aired tap water are put *Stentor*s from the vegetation.
Airing.
At 1.04 p.m. a young rudd is inserted.
- 1.12 — it floats about with the current of the glass.
- 1.16 — the respiration is weak.
- 1.30 — it is still breathing.
- 1.45 — the respiration has stopped.

Experiment C. 3/6-IX-43.

A branch of *Elodea* with *Stentor*s on it is put into a glass with tap water. The glass is left alone for the night, and the next morning the *Stentor*s that had loosened from the *Elodea* during the transfer have gathered on the plant once more. At 10.58 a.m. on 4-IX a young rudd is put into the glass. The water is quiet, not being aired.
At 1.15 p.m. nothing abnormal about the fish is observed.
- 11.16 a.m. on 6-IX the fish is still well and the experiment is stopped. The *Stentor*s are used again for Experiments F and G.

Experiment D. 4-IX-43.

3 glasses { I. unfiltered water from the Lysbro pond, aired for about 45 minutes. Oxygen contents 6.8 ccm./l.
II. filtered water from the Lysbro pond, aired for about 45 minutes. Oxygen contents 6.8 ccm./l.
III. Water from the lake Furesø.

(Measured at the same time in the tub of water from the Lysbro pond: 3.1 ccm. O_2/l., pH 6.8 and no H_2S.)
At 12.28 p.m. 2 rudds are put into each glass without airing.
- 12.35 — 1 fish of glass I and II is lying on its side. The fish of these glasses remain at the surface while the fish of glass III are standing at the bottom.
- 12.36 — 1 fish of glass I and II is lying upside down; the rest in normal position.
- 12.38 — both fishes of glass I are lying upside down; in glass II both are again in normal position, but immediately after one of them turns on its side.
- 12.40 — both fishes of glass I and one of glass II are swimming spasmodically.
At 12.42 p.m. both fishes of glass II are lying upside down, now and then swimming spasmodically.
- 12.45 — all fishes of glasses I and II are lying upside down; they still breathe, and in glass II a little cramp is observed. In glass III both fishes are normal.
- 12.52 — one fish of glass I has died.
- 12.55 — the other fish of glass I has died. Oxygen contents 6.9 ccm./l. 19° C.
- 1.00 — still weak respiration of both fishes of glass II.
- 1.05 — one fish of glass II has died.
- 1.07 — the other fish of glass II has died. Oxygen contents 6.5 ccm./l. 19° C.
Both fishes of glass III are normal.

Lengths of the fish { glass I { 26 mm.
28 —
glass II { 28 —
30 —

It appears from Experiment A that in water from the Lysbro pond the fish are killed in the course of 22—23 minutes by a poisonous effect and not by a mechanical destruction caused by the *Stentor*s because a filtration of the water through common filter-paper, which retained the *Stentor*s, did not alter the effect of the water. Experiment B makes it probable that *Stentor polymorphus* is the bearer of the poison because tap water grows poisonous to fish when *Stentor*s are inserted and the water is stirred by airing. If the water is quiet and the *Stentor*s are fixed to some object (Experiment C), no poisoning takes place even if *Stentor*s are present in quantity. In other words the results of the experiments correspond very well with the observations in the pond: here, too, the fish were all alive as long as the water was quiet but were killed when the water level sank so low that they splashed in the vegetation.

Experiment D is a repetition of Experiment A made in order to show that the fish are not killed by lack of oxygen. In this experiment the fish died after 24—39 minutes, which seems to suggest a decrease of she poisonousness of the Lysbro pond water. This decrease continued until the water seemed to be free from poison on 6-IX-43, as will appear from the following experiment.

Experiment E. 6-IX-43.

2 glasses { I. unfiltered water from the Lysbro pond.
II. water from the Lysbro pond mixed with bruised charcoal and then filtered through filter-paper.

At 11.25 a.m. 1 rudd is put into each glass.
- 3.10 p.m. both fishes are unhurt.
- 6.40 — both fishes are unhurt. Experiment stopped.

Before the water from the Lysbro pond had lost its poisonousness and made further experiments impossible these experiments had shown that we are no doubt dealing with a strong fish poison, the occurrence of which must be connected with *Stentor polymorphus*. The poison only appeared when the *Stentor*s were irritated by being shaken loose or by vigorous movements of the water whereas no poisonous effect could be demonstrated when the *Stentor*s were left alone. The poison thus produced did not retain its effect for a very long time, possibly because the poisonous matter was oxidized. In the water used for Experiment C there has no doubt been poison immediately after the transfer of the *Stentor*s to the glass (see Experiment B), but when the fish were put in the next day, the poisonous effect had disappeared.

As mentioned Experiment C was stopped at 11.15 a.m. on 6-IX, and now another experiment was made in order to see whether the poisonousness of the *Stentor*s had disappeared like that of the water.

Experiment F. 6-IX-43.

A branch of *Elodea* with *Stentor*s from the glass of Experiment C is stirred in Furesø water, and the *Stentor*s are filtered off by means of filter-paper. A rudd of 23 mm. is put into the filtered water at 12.50 p.m. It grows very restless at once, gasps and tries to leap out of the water.

At 12.57 p.m. it turns on its side but straightens again.
- 1.00 — it lies on its side and is hardly able to straighten, but succeeds to do so in leaning against the sides of the glass.
- 1.03 — it darts about for a few times, then remains quiet, "vomits" and "reels" about.
- 1.05 — the respiration grows convulsive, and the fish darts wildly about the glass.
- 1.06 — it is lying on its side with convulsive respiration and quivering fins.
- 1.10 — a few convulsive respirations are still observed at long intervals.
- 1.11 — the last respiration is seen.

The fish died in 21 minutes, a distinct proof that the *Stentor*s, which were harmless when left alone, will kill a fish rapidly when irritated.

In order to establish the effect of the poison on lower animals we made

Experiment G. 6-IX-43.

Some more vegetation with *Stentor*'s on was stirred in the water from Experiment F.

The water was not filtered.

At 2.45 p.m. were inserted: 1 *Oligochæte*, 2 *Asellus aquaticus*, 1 larval *Trichoptera*, 1 larval *Tanypodiin* and 1 red (undetermined) larval *Chironomid*.
- 6.40 — all the animals were unhurt, and the experiment was stopped.

In other words no poisonous effect on the animals in question could be established.

The pure cultivation of the *Stentor*s and their symbionts proved to be rather difficult, and it was not until the end of October 1943 that Mag. scient. Nils Andrésen succeeded in getting the cultures so good, that experiments could be made with them.

About 1.000 of the cultivated *Stentor*s, which were still in possession of their symbionts, were put into 7 ccm. of filtered tank water together with a small toothed carp (*Lebistes*). The fish seemed to be none the worse and lived together with the *Stentor*s for 24 hours, after which it was removed to a tank without *Stentor*s where it lived on. Apparently it had eaten some of the *Stentor*s during its stay in the *Stentor* water. In other words no poisonous effect was observed in spite of the fact that the movements of the fish in the small body of water must have irritated the *Stentor*s to a considerable degree.

The same result was achieved when a *Lebistes* was put into 5 ccm. of tank water, to which had been added a pure cultivation of algae from the *Stentor*s in such amounts, that the concentration of algae was 2.000 per 1 ccm. Also this fish was all alive after 24 hours.

In this respect the *Stentor*s are thus much like the flagellate *Prymnesium parvum*, which also looses its poisonousness when cultivated[1]).

In other words it appears from observations and experiments that water in which *Stentor polymorphus* have been stirred becomes poisonous to fish but not to the lower animals used in Experiment G. Unirritated *Stentor*s have no poisonous effect, and neither cultivated, irritated *Stentor*s nor cultivated alga symbionts from the *Stentor*s make the water poisonous. The poisonousness of the water treated with *Stentor*s is limited in time because the poisonous matter is probably decomposed. The cause of the poisonous effect is far from being established through the few experiments, but the following is a working

[1]) The possibility cannot be totally waived that *Lebistes* may have been resistant against a poison possibly present. Young rudds could not be procured at the time of the experiments.

hypothesis: the damage to the fish is done by some matter that is excreted by *Stentor polymorphus* when it is irritated. It is unknown whether this matter must be considered a means of defence or a metabolic product or whether it is produced by *Stentor polymorphus* itself, by its symbiotic algae (*Chlorella vulgaris*) or perhaps by consumed bacteria.

The poisonous effect of *Stentor* recalls not only the poisonousness of *Prymnesium parvum* but also that of the snail *Limnaea peregra*[1]). It was planned to attempt a further encircling of the supposed poisonous matter in 1944, but no trout died during the depletion on 21-VIII-44, and *Stentor polymorphus* could not be found in the pond. Mr. Errboe later on informed us by post that the poisoning in 1943 was moreover observed during later depletions of ponds near the Lysbro pond farm, but the extent of the damage was not so considerable in these cases because most of the fish were saved by a transfer in due time to other waters.

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[1]) H. Wundsch: Ausscheidungen der Wasserschnecke *Limnaea peregra* (Müll.) als raschwirkendes Fischgift. (Zeitschrift für Fisherei und deren Hilfswissenschaften. Bd. XXVIII, 1930).

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